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OF

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FOR

1922.

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THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN



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1922

CONTENTS.

VOLUME LVI.

PAGE.

ART. I.—PRESIDENTIAL ADDRESS. By E. C. ANDREWS, B.A., F.G.S. (Issued June 30th, 1922.) 1

ART. II.—The position of the double linkage in Piperitone, Part II, with notes on some of its derivatives. By A. R. PENFOLD, F.C.S. (Issued July 17th, 1922.)... 39

ART. III.—The Incidence of Anthrax in Stock in Australia. By MAX HENRY, D.S.O., B.V.Sc., M.R.C.V.S. (Issued July 17th, 1922.) 44

ART. IV.—Notes on the species of the genera *Darwinia Homoranthus* and *Rylestonea* in New South Wales, Queensland and South Australia. By EDWIN CHEEL. (Issued August 8th, 1922.) 62

ART. V.—Notes on *Melaleuca linariifolia* Sm. and *M. trichostachya* Lind. By EDWIN CHEEL. (Issued August 8th, 1922). ... 78

ART. VI. —Observations respecting some Essential Oils from *Leptospermum Liversidgei*. By A. R. PENFOLD, F.C.S. (Issued September 14th, 1922.) 82

ART. VII.—Preliminary Note on a new Stearoptene (probably a phenol ether) occurring in some Essential Oils of the Myrtaceæ. By A. R. PENFOLD, F.C.S., and F. R. MORRISON. (Issued September 14th, 1922.) 87

ART. VIII.—A Chemical and Bacteriological Study of a typical wheat soil of New South Wales. By J. K. TAYLOR, B.Sc. (Agr.). (Issued September 19th, 1922.)... 90

ART. IX.—The Miscibility Test for Eucalyptus Oils. By Prof. C. E. FAWSITT, D.Sc., Ph.D., and C. H. FISCHER. (Issued November 13th, 1922) 109

ART. X.—On the Australian Melaleucas and their Essential Oils. Part VI. By R. T. BAKER, and H. G. SMITH, F.C.S. [*With Plate I.*] (Issued November 13th, 1922.) 115

ART. XI.—The Essential Oil of *Backhousia myrtifolia* (Hooker and Harvey), Part I. By A. R. PENFOLD, F.C.S. (Issued November 13th, 1922.) 125

ART. XII.—Acacia Seedlings, Part VIII, By R. H. CAMBAGE, F.L.S. [*With Plates II – V, and text figure.*] (Issued November 24th, 1922.) 130

ART. XIII.—Note on the Relationship between Oil Glands and Oil Yields in the Eucalyptus. By M. B. WELCH, B.Sc. (Issued November 24th, 1922.) 149

PAGE

ART. XIV.—Poisoning of Sheep by *Solanum cinereum*. By SYDNEY DODD, F.R.C.V.S., D.V.Sc. (Issued November 24th, 1922). ... 153

ART. XV.—On the Occurrence of l-Phellandrene in the Oil of *Melaleuca acuminata*, of South Australia. By H. G. SMITH, F.C.S. (Issued November 24th, 1922.)... 159

ART. XVI.—The Essential Oils of two Leptospermums By A. R. PENFOLD, F.C.S. (Issued November 24th, 1922.) 162

ART. XVII.—The Stereoisomeric Forms of Menthone. By R. S. HUGHESDON, H. G. SMITH, F.C.S., and JOHN READ, M.A., PH.D., B.Sc. (Issued November 24th, 1922) 170

ART. XVIII.—A Contribution to the Chemistry of the Phellandrenes. By E. HURST, H. G. SMITH, F.C.S., and JOHN READ, M.A., PH.D., B.Sc. (Issued November 24th, 1922.) 176

ART. XIX.—Notes on the Chemistry of certain Australian Plant Products, Part I. By H. G. SMITH, F.C.S. [*With Plate VI.*] (Issued November 24th, 1922.) 180

ART. XX.—Notes on Plate Exposures and the subsequent Photographic Treatment adopted by the Sydney University Eclipse Expedition. By EDGAR H. BOOTH, B.Sc. [*With Plates VII–VIII.*] (Issued November 24th, 1922.) 185

ART. XXI.—The Essential Oils of two species of Homoranthus and the Occurrence of Ocimene. By A. R. PENFOLD, F.C.S. (Issued 31st January, 1923.) 193

ART. XXII.—The Essential Oil of *Kunzea corifolia*. By F. R. MORRISON. (Issued January 31st, 1923.) 201

ART. XXIII.—Notes on the Food Value of the Snapper and on the Constants of Whale Oil. By W. M. DOHERTY, F.I.C., F.C.S. (Issued January 31st, 1923.) 206

ART. XXIV.—Notes on Hornblende and Bytownite from Hypersthene Gabbro, Black Bluff, near Broken Hill. By Miss IDA A. BROWN, B.Sc., (communicated by W. R. BROWNE, D.Sc.) (Issued March 15th, 1923.) 210

ART. XXV.—The Economic Utilisation of the Residues from the Steam Rectification of the Essential Oil of *Eucalyptus cneorifolia* and the Germicidal Values of the Pure 'Active' Constituents. By A. R. PENFOLD, F.C.S., and R. GRANT, F.C.S. (Issued March 15th, 1923.) 219

ART. XXVI.—The Essential Oil of *Eriostemon Crowei* (*Crowea saligna*) and the presence of a new Phenol Ether. By A. R. PENFOLD, F.C.S. and F. R. MORRISON. (Issued March 15th, 1923.) 227

ART. XXVII.—The Resinous Exudation of Rosewood. By M. B. WELCH, B.Sc., A.I.C. [*With Plates IX–X.*] (Issued March 15th, 1923) 233

PAGE

ART. XXVIII.—A Method of Identification of some Hardwoods. By M. B. WELCH, B.Sc., A.I.C. (Issued March 15th, 1923.) .. 241

ART XXIX.—Notes on the Occurrence of Gastrioceras, at the Irwin River Coal-Field, W.A., and a comparison with the so-called Paralegoceras from Letti, Dutch East Indies. By W. S. DUN, and Sir EDGEWORTH DAVID, K.B.E., D.S.O., C.M.G., D.Sc., F.R.S. [*With Plates XI - XIII.*] (Issued March 15th, 1923.)... 249

ART. XXX.—The Glucoside occurring in the timber of the 'Red Ash.' *Alphitonia excelsa*, Reiss By H. G. SMITH, F.C.S. and JOHN READ, M.A., Ph D , B.S.c. (Issued March 15th, 1923.) ... 253

ART. XXXI.—On an Olivine-bearing Quartz-Monzonite from Kiandra, N.S.W. By W. R BROWNE, D.Sc., and W. A. GREIG. [*With Plate XIV.*] (Issued March 15th, 1923.) 260

ART. XXXII.—Note on the Occurrence of Calcite in a Basalt from the Maitland District, N.S W. By W. R. BROWNE, D.Sc. [*With Plate XV.*] (Issued March 15th, 1923.) 278

ART. XXXIII.—Notes on the Bacteriological Aspect of Pasteurisation of Milk for Cheddar Cheese-making. By J. K. MURRAY, B.A., B.Sc., (communicated by R. D. WATT, M.A., B.Sc (Issued March 15th, 1923.) 285

ABSTRACT OF PROCEEDINGS ... ... i. – xxii.

PROCEEDINGS OF THE GEOLOGICAL SECTION .. ... xxiii. – xxxi.

PROCEEDINGS OF THE AGRICULTURAL SECTION ... .. xxxiii. – xl.

PROCEEDINGS OF THE SECTION OF INDUSTRY ... ... xl. xliv.

TITLE PAGE, CONTENTS, NOTICES, PUBLICATIONS, ... (i – vi.)

OFFICERS FOR 1921-1922... ... ... (vii.)

LIST OF MEMBERS, &c. ... ... (ix.)

INDEX TO VOLUME LVI .. .. xlv.

PUBLICATIONS.

———o———

The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.

Vols.	I—XI	Transactions of the Royal Society, N.S.W.,					1867—1877,	,,
,,	XII	Journal and Proceedings			,,	,,	1878, ,, 324,	price 10s.6d.
,,	XIII	,,	,,	,,	,,	,,	1879, ,, 255,	,,
,,	XIV	,,	,,	,,	,,	,,	1880, ,, 391,	,,
,,	XV	,,	,,	,,	,,	,,	1881, ,, 440,	,,
,,	XVI	,,	,,	,,	,,	,,	1882, ,, 327,	,,
,,	XVII	,,	,,	,,	,,	,,	1883, ,, 324,	,,
,,	XVIII	,,	,,	,,	,,	,,	1884, ,, 224,	,,
,,	XIX	,,	,,	,,	,,	,,	1885, ,, 240,	,,
,,	XX	,,	,,	,,	,,	,,	1886, ,, 396,	,,
,,	XXI	,,	,,	,,	,,	,,	1887, ,, 296,	,,
,,	XXII	,,	,,	,,	,,	,,	1888, ,, 390.	,,
,,	XXIII	,,	,,	,,	,,	,,	1889, ,, 534,	,,
,,	XXIV	,,	,,	,,	,,	,,	1890, ,, 290,	,,
,,	XXV	,,	,,	,,	,,	,,	1891, ,, 348,	,,
,,	XXVI	,,	,,	,,	,,	,,	1892, ,, 426,	,,
,,	XXVII	,,	,,	,,	,,	,,	1893, ,, 530,	,,
,,	XXVIII	,,	,,	,,	,,	,,	1894, ,, 368,	,,
,,	XXIX	,,	,,	,,	,,	,,	1895, ,, 600,	,,
,,	XXX	,,	,,	,,	,,	,,	1896, ,, 568,	,,
,,	XXXI	,,	,,	,,	,,	,,	1897, ,, 626,	,,
,,	XXXII	,,	,,	,,	,,	,,	1898, ,, 476,	,,
,,	XXXIII	,,	,,	,,	,,	,,	1899, ,, 400,	,,
,,	XXXIV	,,	,,	,,	,,	,,	1900, ,, 484,	,,
,,	XXXV	,,	,,	,,	,,	,,	1901, ,, 581,	,,
,,	XXXVI	,,	,,	,,	,,	,,	1902, ,, 531,	,,
,,	XXXVII	,,	,,	,,	,,	,,	1903, ,, 663,	,,
,,	XXXVIII	,,	,,	,,	,,	,,	1904, ,, 604,	,,
,,	XXXIX	,,	,,	,,	,,	,,	1905, ,, 274,	,,
,,	XL	,,	,,	,,	,,	,,	1906, ,, 368,	,,
,,	XLI	,,	,,	,,	,,	,,	1907, ,, 377,	,,
,,	XLII	,,	,,	,,	,,	,,	1908, ,, 593,	,,
,,	XLIII	,,	,,	,,	,,	,,	1909, ,, 466,	,,
,,	XLIV	,,	,,	,,	,,	,,	1910, ,, 719,	,,
,,	XLV	,,	,,	,,	,,	,,	1911, ,, 611,	,,
,,	XLVI	,,	,,	,,	,,	,,	1912, ,, 275,	,,
,,	XLVII	,,	,,	,,	,,	,,	1913, ,, 318,	,,
,,	XLVIII	,,	,,	,,	,,	,,	1914, ,, 584,	,,
,,	XLIX	,,	,,	,,	,,	,,	1915, ,, 587,	,,
,,	L	,,	,,	,,	,,	,,	1916, ,, 362,	,,
,,	LI	,,	,,	,,	,,	,,	1917, ,, 786,	,,
,,	LII	,,	,,	,,	,,	,,	1918, ,, 624,	,,
,,	LIII	,,	,,	,,	,,	,,	1919, ,, 414,	,,
,,	LIV	,,	,,	,,	,,	,,	1920, ,, 312,	price £1 1s.
,,	LV	,,	,,	,,	,,	,,	1921, ,, 418,	,,
,,	LVI	,,	,,	,,	,,	,,	1922, ,, 372,	,,

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† Succeeded by CHARLES HEDLEY, F.L.S., from 28th June, 1922.

NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors of papers desiring illustrations are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is $4\frac{1}{4}$ in. $\times 6\frac{3}{4}$ in. The cost of all original drawings, and of colouring plates must be borne by Authors.

ERRATA.

Page 161, line 16, to the left should read to the right.

,, 225, line 2, for 32·5% ethyl alcohol solution has a co-efficient of 0·031 read ethyl alcohol has a co-efficient of 0·031.

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I bequeath the sum of £ to the ROYAL SOCIETY OF NEW SOUTH WALES, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

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1906		Colley, David John K., Pennant Hills Road, Normanhurst viâ Wahroonga.
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1919		Cotton, Frank Stanley, B.Sc., Chief Lecturer and Demonstrator in Physiology in the University of Sydney.
1909	P 5	Cotton, Leo Arthur, M.A., D.Sc., Assistant Professor of Geology in the University of Sydney.
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1912		Curtis, Louis Albert, L.S., Hampton Court, Bayswater Road, Darlinghurst.
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1876	P 3	Darley, Cecil West, M. INST. C.E., 'Longheath,' Little Bookham, Surrey, England; Australian Club, Sydney.
1886	P 23	David, Sir Edgeworth, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., Professor of Geology and Physical Geography in the University of Sydney; p.r. 'Coringah,' Sherbrooke-street, Hornsby. (President 1895, 1910.)
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1916		Dixon, Jacob Robert L., M.R.C.S., L.R.C.P., Demonstrator in Physiology in the University of Sydney.
1906		Dixson, William, 'Merridong,' Gordon Road, Killara.
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1913	P 1	Dodd, Sydney, D.V.Sc., F.R.C.V.S., Lecturer in Veterinary Pathology in the University of Sydney.
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1918		Elliott, Edward, c/o Reckitts' (Oversea) Ltd., Bourke-street, Redfern.
1916	P 2	Enright, Walter J., B.A., High-street, West Maitland, N.S.W.
1908		Esdaile, Edward William, 42 Hunter-street.
1896		Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street.
1887		Faithfull, R. L., M.D., *New York*, L.R.C.P., L.S.A. *Lond.*, c/o Iceton, Faithfull and Maddocks, 25 O'Connell-street.
1902		Faithfull, William Percy, 'The Monastery,' Kurraba Road, Neutral Bay.
1921		Farnsworth, Henry Gordon, 'Rothsay,' 90 Alt-street, Ashfield.
1910		Farrell, John, Riverina Flats, 265 Palmer-street, Sydney.
1909	P 6	Fawsitt, Charles Edward, D.Sc., Ph.D., Professor of Chemistry in the University of Sydney. (President 1919). *Vice-President.*
1922		Ferguson, Andrew, 9 Martin Place, Sydney.
1920	P 1	Ferguson, Eustace William, M.B., Ch.M., 'Timbrabongie,' Gordon Road, Roseville.
1881		Fiaschi, Thos., M.D., M.Ch. *Pisa*, 'Beanbah,' 235 Macquarie-st.
1920		Fisk, Ernest Thomas, Wireless House, 97 Clarence-street.
1888		Fitzhardinge, His Honour Judge G. H., M.A., 'Red Hill,' Beecroft.
1922		Fleming, Edward Patrick, Under Secretary for Lands, Lands Department, Sydney.
1921		Fletcher, Joseph James, M.A., B.Sc., 'Ravenscourt,' Woolwich Road, Woolwich.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.* L.R.C.P. *Edin.*, 'Wyoming,' Macquarie-street.
1920		Fortescue, Albert John, 'Benambra,' Loftus-street, Arncliffe.
1905		Foy, Mark, Elizabeth and Liverpool-streets.

Elected		
1904		Fraser, James, C.M.G., M. INST. C.E., Chief Commissioner for Railways, Bridge-street; p.r. 'Arnprior,' Neutral Bay.
1907		Freeman, William, 'Ghyll Grange,' 50 Muston-st., Mosman.
1881		Furber, T. F., F.R.A.S., L.S., c/o Dr. R. I. Furber, 'Sunnyside,' Stanmore Road, Stanmore.
1917		Galbraith, Augustus Wm., M. INST. C.E I., F.S.E., F.R.San.I., City Engineer, Perth, W.A.
1918		Gallagher, James Laurence, M.A. *Syd.*, 'Akaroa,' Ellesmere Avenue, Hunter's Hill.
1921		Godfrey, Gordon Hay, M.A., B.Sc., Lecturer in Physics in the Technical College, Sydney; p.r. 262 Johnston-street, Annandale.
1897		Gould, The Hon. Sir Albert John, K.B., V.D., 'Eynesbury,' Edgecliff.
1922	P 1	Grant, Robert, F.C.S., Department of Public Health, 93 Macquarie-street.
1916		Green, Victor Herbert, 7 O'Connell-street.
1922	P 1	Greig, William Arthur, Mines Department, Sydney.
1899	P 1	Greig-Smith, R., D.Sc. *Edin.*, M.Sc. *Dun.*, Macleay Bacteriologist, Linnean Society's House, Ithaca Road, Elizabeth Bay. (President 1915.)
1912		Grieve, Robert Henry, B.A., 'Langtoft,' Llandaff-st., Waverley.
1912		Griffiths, F. Guy, B.A., M.D., Ch M., 'Woolgan,' Lane Cove Road, Killara.
1919		Grutzmacher, Frederick Lyle, F.C.S., Church of England Grammar School, North Sydney.
1891	P 16	Guthrie, Frederick B., F.I.C., 77 Kurraba Road, Neutral Bay. (President 1903).
1919		Hack, Clement Alfred, Collins House, 360 Collins-street, Melbourne.
1880	P 5	Halligan, Gerald H., L.S., F.G.S., 97 Elphin Road, Launceston, Tasmania.
1912		Hallmann, E. F., B.Sc., 75 Hereford-street, Forest Lodge.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1919		Hambridge, Frank, 58 Pitt-street.
1916	P 1	Hamilton, Arthur Andrew, 'The Ferns,' 17 Thomas-st., Ashfield
1912		Hamilton, Alexander G., 'Tanandra,' Hercules-st., Chatswood.
1887	P 8	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; 'Glendowan,' Glenbrook, Blue Mountains. B.M.A. Building, 30 Elizabeth-st. (President 1899, 1908).
1909		Hammond, Walter L., B.Sc., High School, Broken Hill.
1916		Hardy, Victor Lawson, 'The Laurel,' 43 Toxteth Rd., Glebe Pt.
1905	P 3	Harker, George, D.Sc., Lecturer and Demonstrator in Organic Chemistry in the University of Sydney.
1913	P 1	Harper, Leslie F., F.G.S., Geological Surveyor, Department of Mines, Sydney.
1919		Harrison, Launcelot, B.Sc., *Syd.*, B.A. *Cantab.*, Professor of Zoology in the University of Sydney.

Elected.		
1918		Hassan, Alex. Richard Roby, c/o W. Angliss & Co. Ppty. Ltd., 64 West Smithfield, London, E.C.
1884	P 1	Haswell, William Aitcheson, M.A., D.Sc., F.R.S., Emeritus Professor of Zoology and Comparative Anatomy in the University of Sydney; p.r. 'Mimihau,' Woollahra Point.
1919		Hay, Alexander, Coolangatta, N.S.W.
1916		Hay Dalrymple-, Richard T., L.S., Chief Commissioner of Forests, N. S. Wales; p.r. Goodchap Road, Chatswood.
1914		Hector, Alex. Burnet, 481 Kent-street.
1891	P 3	Hedley, Charles, F.L.S., Australian Museum, Sydney. (President 1914.)
1899		Henderson, James, F.R.E.S., 'Wahnfried,' Drummoyne.
1916		Henderson, James, 'Dunsfold,' Clanalpine-street, Mosman.
1919		Henriques, Frederick Lester, 56 Clarence-street.
1919	P 1	Henry, Max, D.S.O., B.V.Sc., M.R.C.V.S., 'Coram Cottage,' Essex-street, Epping.
1884	P 1	Henson, Joshua B., ASSOC. M. INST. C.E., Hunter District Water Supply and Sewerage Board, Newcastle.
1918		Hindmarsh, Percival, M.A., B.Sc. (Agr.), Teachers' College, The University, Sydney.
1921		Hindmarsh, William Lloyd, B.V.Sc., M.R.C.V.S., D.V.H., Stock Branch, Department of Agriculture, Sydney.
1920		Hinds, Herbert Henry, 484 Kent-street, Sydney.
1916		Hoggan, Henry James, 'Lincluden,' Frederick-st., Rockdale.
1901		Holt, Thomas S., 'Amalfi,' Appian Way, Burwood.
1905	P 3	Hooper, George, F.T.C. *Syd.*, Assistant Superintendent, Sydney Technical College; p.r. 'Nyeumbene,' Nielson Park, Vaucluse.
1920		Hordern, Anthony, c/o Messrs. A. Hordern & Sons Ltd., Brickfield Hill.
1919		Horsfall, William Nichols, M.B., B.S. *Melb.*, Lecturer and Demonstrator in Physiology in the University of Sydney.
1919		Hoskins, Arthur Sidney, Eskroy Park, Bowenfels.
1919		Hoskins, Cecil Harold, Windarra, Bowenfels.
1891	P 1	Houghton, Thos. Harry, M. INST. C.E., M. I. MECH. E., 63 Pitt-st. (President 1916),
1919		Houston, Ralph Liddle, 'Noorong,' Cooper-street, Strathfield.
1906		Howle, Walter Cresswell, L.S.A. *Lond.*, 'Lugano,' 244 Military Road, Mosman.
1913		Hudson, G. Inglis, J.P., F.C.S., 'Gudvangen,' Arden-st., Coogee.
1920		Hulle, Edward William, Commonwealth Bank of Australia.
1919		Hunt, Charles James, B.A., Lindsay-street, East Maitland.
1921		Jackson, Frederick Henry, 22 Carrington-st., Wynyard Square.
1922		Jacobs, Ernest Godfried, 'Goulburnia,' Banks-street, Ashfield.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Chief Inspector of Mines, Department of Mines, Sydney.
1917		Jenkins, Richard Ford, Engineer for Boring, Irrigation Commission, 6 Union-street, Mosman.
1918		Johns, Morgan Jones, A.M.I.E.E. *Lond.*, M.I.E. *Aust.*, M.I.M. *Aust.*, Box 2, P.O., Mount Morgan, Queensland.
1909	P 15	Johnston, Thomas Harvey, M.A., D.Sc., F.L.S., C.M.Z.S., Professor of Zoology in the University of Adelaide.

Elected		
1911		Julius, George A., B.Sc., M.E., M. I. MECH. E., Culwulla Chambers, Castlereagh-street, Sydney.
1883		Kater, The Hon. H. E., J.P., M.L.C., Australian Club, Macquarie-street.
1876	P 4	Keele, Thomas William, L.S., M.INST.C.E., 'Gladsmuir,' Rivers-street, Woollahra.
1914		Kemp, William E., A.M. INST. C.E., Public Works Department. Coff's Harbour Jetty.
1887		Kent, Harry C., M.A., F.R.I.B.A., Dibbs' Chambers, 58 Pitt-st.
1919	P 1	Kesteven, Hereward Leighton, D.Sc., M.D., Ch.M., Bulladelah, New South Wales.
1901		Kidd, Hector, M. INST. C.E., M. I. MECH. E., Cremorne Road, Cremorne.
1896		King, Kelso, 14 Martin Place.
1920		Kirchner, William John, B.Sc., 'Clyde,' Cavendish-street, Concord West.
1919		Kirk, Robert Newby, 25 O'Connell-street.
1881	P 23	Knibbs, G. H., C.M.G., F.S.S., F.R.A.S., L.S., Director, Commonwealth Institute of Science and Industry, Member Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild, 314 Albert-street East Melbourne. (President 1898).
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1911	P 3	Laseron, Charles Francis, Technological Museum.
1913		Lawson, A. Anstruther, D.Sc., F.R.S.E., F.L.S., Professor of Botany in the University of Sydney.
1906		Lee, Alfred, 'Glen Roona,' Penkivil-street, Bondi.
1920		Le Souef, Albert Sherbourne, Taronga Park, Mosman.
1916		L'Estrange, Walter William, 7 Church-street, Ashfield.
1909		Leverrier, Frank, B.A., B.Sc., K.C., 182 Phillip-street.
1883		Lingen, J. T., M.A. *Cantab.*, K.C., University Chambers, 167 Phillip-street, Sydney.
1906		Loney, Charles Augustus Luxton, M. AM. SOC. REFR. E., Equitable Building, George-street.
1884		MacCormick, Sir Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street.
1887		MacCulloch, Stanhope H., M.B., Ch M. *Edin.*, 24 College-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co., Ld., Hunter-street, Sydney.
1922		MacKay, Alexander Clarke, c/o British Consul, Harbin, Manchuria.
1876		Mackellar, The Hon. Sir Charles Kinnaird, K.C.M.G., M.L.C., M.B., C.M. *Glas.*, Equitable Building, George-street.
1921		McDonald, Alexander Hugh Earle, Department of Agriculture, Sydney.
1903		McDonald, Robert, J.P., L.S., Pastoral Chambers, O'Connell-st; p.r. 'Lowlands,' William-street, Double Bay,

Elected		
1891		McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.S. *Lond.*, D.P.H. *Cantab.*, Hospital for the Insane, Gladesville.
1920		McDowall, James Campbell, B.Sc., *N.Z.*, c/o Austral Bronze Co., Ltd., O'Riordan-street, Alexandria.
1919		McGeachie, Duncan, M.I.M.E., M.I.E. (Aust.), M.I.M.M. (Aust.), 'Craig Royston,' Toronto, Lake Macquarie.
1919		McGlynn, William Henry. 'Koora,' Iredale Avenue, Cremorne.
1906		McIntosh, Arthur Marshall, 'Moy Lodge,' Hill-st., Roseville.
1891	P 2	McKay, R. T., L.S., M. INST. C.E., Commissioner, Sydney Harbour Trust, Circular Quay.
1880	P 9	McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M. INST. C.E., Sydney Safe Deposit, Paling's Buildings, Ash-street.
1922		McLuckie, John, M.A., B.Sc., (*Glasgow*), D.Sc. (*Syd.*), Lecturer in Botany in the University of Sydney.
1901	P 1	McMaster, Colin J., L.S., Chief Commissioner of Western Lands; Box 20, G.P.O. Sydney.
1916		McQuiggin, Harold G., B.Sc., Lecturer and Demonstrator in Physiology in the University of Sydney; p.r. 'Berolyn,' Beaufort-street, Croydon.
1909		Madsen, John Percival Vissing, D.Sc., B.E., Professor of Electrical Engineering in the University of Sydney.
1883	P 44	Maiden J. Henry, J.P., I.S.O., F.R.S., F.L.S., F.R.H.S., Hon. Fellow Roy. Soc. S.A.; Hon. Memb. Roy. Soc, W.A.; Netherlands Soc.for Promotion of Industry; Philadelphia College Pharm.; Southern Californian Academy of Sciences; Pharm. Soc. N.S.W.; Brit. Pharm. Conf.; Corr. Fellow Therapeutical Soc., Lond.; Corr. Memb. Pharm. Society Great Britain; Bot. Soc. Edin.; Soc. Nat. de Agricultura (Chile); Soc. d'Horticulture d'Alger; Union Agricole Calédonienne; Soc. Nat. etc., de Chérbourg; Roy. Soc. Tas.; Roy. Soc. Queensl.; Inst. Nat. Genévois; Hon. Vice-Pres. of the Forestry Society of California; Diplomé of the Société Nationale d'Acclimatation de France; Linnean Medallist, Linnean Society; N.S.W. Govt. Rep. of the "Commission Consultative pour la Protection Internat. de la Nature"; Corr. Memb. National Acclimatisation Society of France; Government Botanist and Director, Botanic Gardens, Sydney. (President 1896, 1911.)
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1920	P 1	Mann, Cecil William, 'Pentreath,' Fairview-street, Arncliffe.
1920		Mann, James Elliott Furneaux, Barrister at Law, 163 Phillip-street.
1908		Marshall, Frank, C.M.G., B.D.S., 151 Macquarie-street.
1914		Martin, A. H., Technical College, Sydney.
1912		Meldrum, Henry John, p.r. 'Craig Roy,' Sydney Rd., Manly.
1905		Miller, James Edward, Albury, New South Wales.
1922		Mills, Arthur Edward, M.B., Ch.M., Dean of the Faculty of Medicine, Professor of Medicine in the University of Sydney, 139 Macquarie-street.
1889	P 8	Mingaye, John C. H., F.I.C., F.C.S., Assayer and Analyst to the Department of Mines; p.r. Campbell-street, Parramatta.
1879		Moore, Frederick H., Union Club, Sydney.
1921		Morris, Albert, 74 Cornish-street, Railway Town, Broken Hill.
1922	P 4	Morrison, Frank Richard, Assistant Chemist, Technological Museum, Sydney; p.r. Brae-street, Waverley.

Elected		
1879		Mullins, John Francis Lane, M.A. *Syd.*, M.L.C., 'Killountan,' Double Bay.
1915		Murphy, R. K., Dr. Ing., Chem. Eng., Lecturer in Chemistry, Technical College, Sydney.
1893	P 4	Nangle, James, O.B.E., F.R.A.S., Superintendent of Technical Education, The Technical College, Sydney; p.r. 'St. Elmo,' Tupper-st., Marrickville. (President 1920.) *Vice-President.*
1917		Nash, Norman C., 'Ruanora,' Lucas Road, Burwood,
1891		‡Noble, Edward George, L.S., 8 Louisa Road, Balmain.
1920		Noble, Robert Jackson, M.Sc., B.Sc., (Agr), 'Lyndon,' Carrington street, Homebush.
1919		Oakden, Frank, C.E., 33 Hunter-street.
1903		‡Old, Richard, 'Waverton,' Bay Road, North Sydney.
1921		Olding, George Henry, 'Tufra,' Napier-street, Drummoyne.
1913		Ollé, A. D., F.C.S., 'Kareema,' Charlotte-street, Ashfield.
1896		Onslow, Col. James William Macarthur, B.A., LL.B, 'Gilbulla,' Menangle.
1917		Ormsby, Irwin, 'Caleula,' Allison Road, Randwick.
1891		Osborn, A. F., Assoc. M. Inst. C.E., Water Supply Branch, Sydney, 'Uplands,' Meadow Bank, N.S.W.
1921	P 2	Osborne, George Davenport, B.Sc, Demonstrator in Geology in the University of Sydney; p.r. 'Belle-Vue,' Kembla-st., Arncliffe.
1920		Paine, William Horace, State Abattoirs, Homebush Bay, N.S.W.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby
1921		Parkes, Varney, Royal Chambers, Castlereagh-street.
1920	P 16	Penfold, Arthur Ramon, F.C.S., Economic Chemist, Technological Museum, Harris-street, Ultimo.
1899		Peterson, T. Tyndall, F.C.P.A., E.S. & A. Bank Building, King and George-streets.
1918		Petrie, James Matthew, D.Sc, F.I.C, Research Fellow of the Linnean Society in Biochemistry, The University, Sydney.
1909	P 2	Pigot, Rev. Edward F., S.J., B.A., M.B. *Dub.*, Director of the Seismological Observatory, St. Ignatius' College, Riverview.
1879	P 8	Pittman, Edward F., Assoc. R.S.M., L.S., c/o The Bank of New South Wales, Collins-street, Melbourne.
1881		Poate, Frederick, F.R.A.S, L.S., 'Clanfield,' 50 Penkivil-street, Bondi.
1919		Poate, Hugh Raymond Guy, M.B., Ch. M. *Syd.*, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 225 Macquarie-street.
1917		Poole, William, B.E., (Civil, Min. and Met.) *Syd.*, M. Inst. C.E., M.I.M.M., M.I.E., Aust., M.Am. I.M.E., M. Aust. I. M.M., L.S., Memb. Intern. Assoc. Testing Materials, 906 Culwulla Chambers, Castlereagh-street.
1896		Pope, Roland James, B.A., *Syd.*, M.D., C.M., F.R.C.S., *Edin.*, 185 Macquarie-street.

Elected		
1910		Potts, Henry William, F.L.S., F.C.S., c/o Lindley Walker & Co., Ltd., Mark Lane, Sussex-street, Sydney.
1921	P 2	Powell, Charles Wilfrid Roberts, A.I.C., c/o Colonial Sugar Refining Co., O'Connell-street.
1918		Powell, John, 170-2 Palmer-street.
1919		Pratten, Herbert E., M.H.R., 26 Jamieson-street.
1918		Priestley, Henry, B.Sc., M.D., Ch.M., Associate-Professor of Physiology in the University of Sydney.
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 193 Macquarie-street.
1912	P 2	Radcliff, Sidney, F.C.S., Department of Chemistry, The University of Sydney.
1922		Raggatt, Harold George, B.Sc., Lord-street, Roseville.
1919	P 3	Ranclaud, Archibald Boscawen Boyd, B.Sc., B.E., Lecturer in Physics, Teachers' College, The University, Sydney.
1916	P 4	Read, John, M.A., Ph.D., B.Sc., Professor of Organic Chemistry in the University of Sydney.
1909		Reid, David, 'Holmsdale,' Pymble.
1914		Rhodes, Thomas, 'High Coombe,' Carlingford.
1920		Richardson, John James, A.M.I.E.E. *Lond.*, 'Kurrawyba,' Upper Spit Road, Mosman.
1921		Robertson, Frederick Arnold, Science Master, Sydney C. of E. Grammar School, North Sydney.
1915		Ross, A. Clunies, B.Sc., c/o G. R. W. McDonald, 32 Elizabeth-st.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, 225 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1897		Russell, Harry Ambrose, B.A., c/o Sly and Russell, 369 George-street; p.r. 'Mahuru,' Park Road, Bowral.
1922		Sandy, Harold Arthur Montague, 326 George-street.
1917		Sawkins, Dansie T., M.A., B.A., 'Brymedura,' Kissing Point Road, Turramurra.
1920		Sawyer, Basil, B E. 'Birri Birra,' The Crescent, Vaucluse.
1920		Scammell, Rupert Boswood, B.Sc., *Syd.*, 18 Middle Head Road, Mosman.
1913		Scammell, W. J., Mem. Pharm. Soc. *Grt. Brit.*, 18 Middle Head Road, Mosman.
1892	P 1	Schofield, James Alexander, F.C.S., A.R.S.M., Associate-Professor of Chemistry in the University of Sydney.
1919		Sear, Walter George Lane, 14 Roslyndale Avenue, Woollahra.
1921		Sellers, Alfred Edward Oswald, M.I.M.E., M.A.I.E., Bellambi.
1904	P 1	Sellors, Richard P., B.A. *Syd.*, 'Mayfield,' Wentworthville.
1918		Sevier, Harry Brown, c/o Lewis Berger and Sons (Aust.) Ltd., 38a Pitt-street.
1883	P 4	Shellshear, Walter, M. INST. C.E., Mitchell-street, Greenwich Point, Greenwich.
1917		Sibley, Samuel Edward, Mount-street, Coogee.
1900		Simpson, R. C., Lecturer in Electrical Engineering, Technical College, Sydney.
1910		Simpson, William Walker, 'Abbotsford,' Leichhardt-street, Waverley.

Elected		
1882		Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. 'Broomage,' Kangaroo-street, Manly.
1893	P 62	Smith, Henry G., F.C.S., 'Dunbourne,' Shirley Road, Roseville. (President 1913.)
1916		Smith, Stephen Henry, Under Secretary and Director of Education, Department of Education, Sydney.
1922		Smith, Thomas Hodge, Australian Museum, Sydney.
1919		Southee, Ethelbert Ambrook, O.B.E., M.A., B.Sc., Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1921		Spencer-Watts, Arthur, 'Araboonoo,' Glebe-street, Randwick.
1917		Spruson, Wilfred Joseph, Daily Telegraph Building, King-st.
1916		Stephen, Alfred Ernest, F.C.S., 801 Culwulla Chambers, 67 Castlereagh-street, Sydney.
1921		Stephen, Henry Montague, B.A., LL.B., 167 Phillip-street.
1914		Stephens, Frederick G. N., F.R.C.S., M.B., Ch.M., 13 Dover Road, Rose Bay.
1920	P 1	Stephens, John Gower, B.Sc., St. Andrew's College, The University, Sydney.
1913		Stewart, Alex. Hay, B.E., 165 Wardell Road, Dulwich Hill.
1900		Stewart, J Douglas, B.V.Sc., M.R.C.V.S., Professor of Veterinary Science in the University of Sydney; 'Berelle,' Homebush Road, Strathfield.
1903		Stoddart, Rev. A. G., The Rectory, Manly.
1909		Stokes, Edward Sutherland, M.B. *Syd.*, F.R.C.P. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1916	P 1	Stone, W. G., Assistant Analyst, Department of Mines, Sydney.
1919		Stroud, Sydney Hartnett, F.I.C., Lecturer in Pharmacy in the University of Sydney.
1918		Sullivan, Herbert Jay, c/o Lewis Berger and Sons (Aust.) Ltd., Rhodes.
1920		Sulman, John, Warrung-st., McMahon's Point, North Sydney.
1918		Sundstrom, Carl Gustaf, c/o Federal Match Co., Park Road, Alexandria.
1901	P 9	Sussmilch, C. A., F.G.S., Principal of the Technical College, Newcastle, N.S.W. *President.*
1919		Sutherland, George Fife, A.R.C.Sc., *Lond.*, Lecturer in Mechanical Engineering, in the University of Sydney.
1920		Sutton, Harvey, O.B.E., M.D., D.P.H. *Melb*, B.Sc. *Oxon.*, 'Lynton,' Kent Road, Rose Bay.
1919		Swain, Herbert John, B.A. *Cantab.*, B.Sc., B.E. *Syd.*, Lecturer in Mechanical Engineering, Technical College, Sydney.
1917		Tate, Herbert, Bridge Road, Stanmore.
1915	P 2	Taylor, Harold B., B.Sc., Kenneth-street, Longueville.
1893		‡Taylor, James, B.Sc., A.R.S.M. 'Cartref,' Brierly-st., Mosman.
1921	P 2	Taylor, John Kingsley, 16 Ferrier-street, Rockdale.
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1921	P 1	Taylor, Thomas Griffith, D.Sc., B.E., B.A., Associate-Professor of Geography in the University of Sydney.
1920		Tebbutt, Arthur Hamilton, B.A., M.B., D.P.H., 185 Macquarie-st.
1899		Teece, R., F.I.A., F.F.A., Wolseley Road, Point Piper.
1878		Thomas, F. J., 'Lovat,' Nelson-street, Woollahra.

Elected		
1919		Thomas, John, L.S., Chief Mining Surveyor, Mines Department Sydney; p.r. 'Remeura,' Pine and Harrow Roads, Auburn.
1913		Thompson, Joseph, M.A., LL.B., Vickery's Chambers, 82 Pitt-street, Sydney.
1919		Thorne, Harold Henry, B.A. *Cantab.*, B.Sc. *Syd.*, Lecturer in Mathematics in the University of Sydney; p.r. Rutledge-st., Eastwood.
1913		Tietkens, William Harry, 'Upna,' Eastwood.
1916		Tilley, Cecil E., The Sedgwick Museum, The University of Cambridge, Cambridge, England.
1916		Tillyard, Robin John, M.A., D.Sc., F.L.S., F.E.S., Biological Branch, Cawthron Institute, Nelson, New Zealand.
1879		Trebeck, P. C.. 'Banavie,' Bowral.
1900		Turner, Basil W., A.R.S.M., F.C.S., Victoria Chambers, 83 Pitt-st.
1919	P 4	Turner, Eustace Ebenezer, B.A. *Cantab.*, D.Sc. *Lond.*, A.I.C., East London College, Mile End Road, London, E. 1.
1916		Valder, George, J.P., Under Secretary and Director, Department of Agriculture, Sydney.
1890		Vicars, James, M.E., Memb. Intern. Assoc. Testing Materials; Memb. B. S. Guild; Challis House, Martin Place.
1921		Vicars, Robert, Marrickville Woollen Mills, Marrickville.
1892		Vickery, George B., 78 Pitt-street.
1903	P 5	Vonwiller, Oscar U., B.Sc., Professor of Physics in the University of Sydney. *Hon. Secretary.*
1919		Waley, Robert George Kinloch, 63 Pitt-street.
1910		Walker, Charles, 'Lynwood,' Terry Road, Ryde.
1910		Walker, Harold Hutchison, Vickery's Chambers, 82 Pitt-st.
1879	P 1	Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1919		Walkom, Arthur Bache, D.Sc. Linnean Society's House, 23 Ithaca Road, Elizabeth Bay.
1903		Walsh, Fred., J.P., Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, London; Patent Attorney Regd. U.S.A.; Memb. Patent Law Assoc., Washington; Regd. Patent Attorn. Comm. of Aust.; Memb. Patent Attorney Exam. Board Aust.; George and
1901		Wynyard-streets; p.r. 'Walsholme,' Centennial Park, Syd.
1918		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1913	P 4	Ward, Edward Naunton, Superintendent of the Botanic Gardens, Sydney.
		Wardlaw, Hy. Sloane Halcro, D.Sc. *Syd.*, Lecturer and Demonstrator in Physiology in the University of Sydney.
1922		Wark, Blair Anderson, V.C., D.S.O., M.I.Q.C., c/o Thompson and Wark, T. & G. Building, Elizabeth-street; p r. 'Braeside,' Zeta-street, Lane Cove, Sydney.
1883	P 17	Warren, W. H., LL.D., WH. SC., M. INST. C.E., M. AM. SOC. C.E., Member of Council of the International Assoc. for Testing Materials, Professor of Engineering in the University of Sydney. (President 1892, 1902.)
1921		Waterhouse, Gustavus Athol, B.Sc., B.E., F.E.S., Royal Mint, Macquarie-street.

Elected		
1919		Waterhouse, Lionel Lawry, B.E. *Syd*, Lecturer and Demonstrator in Geology in the University of Sydney.
1919	P 1	Waterhouse, Walter L., B.Sc. (*Agr.*), 'Cairnleith,' Archer-st., Chatswood.
1919		Watkin-Brown, Willie Thomas, 24 Brown's Road, Kogarah.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Selbourne Chambers, Phillip-street.
1910		Watson, James Frederick, M.B., Ch M., 'Midhurst,' Woollahra.
1911		Watt, Robert Dickie, M.A., B.Sc., Professor of Agriculture in the University of Sydney.
1920	P 5	Welch, Marcus Baldwin, B.Sc., A.I.C., Economic Botanist, Technological Museum.
1907	P 1	Welch, William, F.R.G S., 'Roto-iti,' Boyle-street, Mosman.
1920	P 1	Wellish, Edward Montague, M.A., Lecturer in Applied Mathematics in the University of Sydney.
1921		Wenholz, Harold, 29 Palace-street, Petersham.
1881		‡Wesley, W. H, London.
1922		Whibley, Harry Clement, 39 Moore-street, Leichhardt.
1909	P 3	White, Charles Josiah, B.Sc., Lecturer in Chemistry, Teacher's College.
1918		White, Edmond Aunger, M.A.I.M E., c/o Electrolytic Refining and Smelting Co of Australia Ltd., Port Kembla, N.S.W.
1892		White, Harold Pogson, F.C S., Assistant Assayer and Analyst, Department of Mines; p r. 'Quantox,' Park Road, Auburn.
1921		Willan, Thomas Lindsay, B Sc., Geological Survey, Department of Mines, Sydney.
1920		Williams, Harry, A.I.C., Challis Flats, Phillip-street.
1917		Willington, William Thos., O.B.E., King-street, Arncliffe.
1890		Wilson, James T, M B., Ch M. *Edin.*, F.R S., Professor of Anatomy in the University of Cambridge, England.
1891		Wood, Percy Moore, L.R.C.P. *Lond*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 8	Woolnough, Walter George D Sc., F.G.S., c/o Geological Department, The University, Sydney.
1916		Wright, George, c/o Farmer & Company, Pitt-street.
1917		Wright, Gilbert, Lecturer and Demonstrator in Agricultural Chemistry in the University of Sydney.
1921		Yates, Guy Carrington, 184 Sussex-street.
1916		Youll, John Gibson, Water Conservation and Irrigation Commission, Leeton, N.S.W.
1918		Young, John Anthony, c/o Lewis Berger and Sons (Aust.) Ltd., 38a Pitt-street.

Honorary Members.

Limited to Twenty.

M.—Recipients of the Clarke Medal.

1914		Bateson, W. H., M.A., F.R.S., Director of the John Innes Horticultural Institution, England, The Manor House, Merton, Surrey, England.
1918		Chilton, Charles, M.A., D.Sc., M.B., C.M., etc., Professor of Biology, Canterbury College, Christchurch, N.Z.

Elected.		
1911		Hemsley, W. Botting, LL.D. (*Aberdeen*), F.R.S., F.L.S., Formerly Keeper of the Herbarium, Royal Gardens, Kew; Korresp. Mitgl. der Deutschen Bot. Gesellschaft; Hon. Memb. Sociedad Mexicana de Historia Natural; New Zealand Institute; Roy. Hort. Soc., London; 16 Osborne Road, Broadstairs, Kent, England.
1914		Hill, James P., D.Sc., F.R.S., Professor of Zoology, University College, London.
1908		Kennedy, Sir Alex. B. W., Kt., LL.D., D. ENG., F.R.S., Emeritus Professor of Engineering in University College, London, 17 Victoria-street, Westminster, London S.W.
1908	P 57	*Liversidge, Archibald, M.A., LL.D., F.R.S., Emeritus Professor of Chemistry in the University of Sydney, 'Fieldhead,' George Road, Coombe Warren, Kingston, Surrey, England. (President 1889, 1900.)
1915		Maitland, Andrew Gibb, F.G.S., Government Geologist of Western Australia.
1912		Martin, C. J., C.M.G., D.Sc, F.R.S., Director of the Lister Institute of Preventive Medicine, Chelsea Gardens, Chelsea Bridge Road, London, S.W.I.
1894		Spencer, Sir W. Baldwin, K.C.M.G., M.A., D.Sc., F.R.S., Emeritus Professor of Biology in the University of Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., LL.D., Sc D., F.R.S., The Ferns, Witcombe, Gloucester, England.
1915		Thomson, Sir J. J., O.M., D.Sc., F.R.S., Nobel Laureate, Master of Trinity College, Cambridge, England.
1921		Threlfall, Sir Richard, K.B.E., M.A., F.R.S., lately Professor of Physics in the University of Sydney.

* Retains the rights of ordinary membership. Elected 1872.

OBITUARY 1922-23.

Ordinary Members.

1877	Belfield, Algernon H.
1879	Bond, Albert
1909	Carne, Joseph Edmund
1919	Hamblin, Charles Oswald
1922	Jira, William G.
1917	McLean, Archibald L.
1887	Pollock, James A.
1879	Thomson, Dugald
1899	Walker, James Thomas

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The Revd. WILLIAM BRANWHITE CLARKE, M.A., F.R.S., F.G.S., etc.,

Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia. The prefix * indicates the decease of the recipient.

Awarded

1878 *Professor Sir Richard Owen, K.C.B., F.R.S.

1879 *George Bentham, C.M.G., F.R.S.

1880 *Professor Thos. Huxley, F.R.S.

1881 *Professor F. M'Coy, F.R.S., F.G.S.

1882 *Professor James Dwight Dana, LL.D.

1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S.

1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.

1885 *Sir Joseph Dalton Hooker, O.M., G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.

1886 *Professor L. G. De Koninck, M.D.

1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.

1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.

1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.

1890 *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.

1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.

1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., LL.D., Sc.D., F.R.S., F.L.S., late Director, Royal Gardens, Kew.

1893 *Professor Ralph Tate, F.L.S., F.G.S.

1895 *Robert Logan Jack, LL.D., F.G.S., F.R.G.S.

1895 *Robert Etheridge, Jnr.

1896 *The Hon. Augustus Charles Gregory, C.M.G., F.R.G.S.

1900 *Sir John Murray, K.C.B., LL.D., Sc.D., F.R.S.

1901 *Edward John Eyre.

1902 *F. Manson Bailey, C.M.G.. F.L.S.

1903 *Alfred William Howitt, D.Sc., F.G.S.

1907 Walter Howchin, F.G.S., University of Adelaide.

1909 Dr. Walter E. Roth, B.A., Pomeroon River, British Guiana, South America.

1912 *W. H. Twelvetrees, F.G.S.

1914 A. Smith Woodward, LL.D., F.R.S., Keeper of Geology, British Museum (Natural History) London.

1915 Professor W. A. Haswell, M.A., D.Sc., F.R.S., The University, Sydney.

1917 Professor Sir Edgeworth David, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., The University, Sydney.

1918 Leonard Rodway, C.M.G., Honorary Government Botanist, Hobart, Tasmania.

1920 *Joseph Edmund Carne, F.G.S.

1921 Joseph James Fletcher, M.A., B.Sc., 'Ravenscourt,' Woolwich.

1922 Richard Thomas Baker, The Avenue, Cheltenham.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

Awarded.

1882 John Fraser, B.A., West Maitland, for paper entitled 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong, for paper entitled 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper entitled 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney, for paper entitled 'The Tin deposits of New South Wales.'

1887 Jonathan Seaver, F.G.S., Sydney, for paper entitled 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.'

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper entitled 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for paper entitled 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.'

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper entitled 'The Australian Aborigines.'

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper entitled 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper entitled 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper entitled the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper entitled 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, D.Sc., M.B., F.R.S., Sydney, for paper entitled 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper entitled 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS.

By E. C. ANDREWS, B.A., F.G.S.

[*Delivered to the Royal Society of N S. Wales, May 3, 1922.*]

DURING the year the work of the Society has progressed in a most satisfactory manner. Eight meetings were held; twenty-four papers were read; the attendance of members was satisfactory, and the discussions of many papers proceeded with interest.

The various sections held highly successful meetings, due to the unflagging energy of their various secretaries.

Popular science lectures were delivered:—"The Aborigines of Central Australia," by Captain S. A. White, on June 7th; "The Economics of the Australian Vegetation, Irrespective of Timber," by H. G. Smith, F.C.S., on July 21st; "Flies as Disease Carriers," by Dr. E. W. Ferguson, on August 18th; "Calculating Machinery," by G. A. Julius, B.Sc., on September 15th, 1921.

The Centenary of our Society was celebrated on the 7th December, and His Excellency Sir Walter Davidson, the Governor of the State and Vice-Patron of the Society, attended by Major Egerton, was the chief guest. Short addresses dealing with the early history of the Society, together with the first papers presented, were delivered by Mr. R. H. Cambage, Professor W. E. Cooke, Professor Sir Edgeworth David, Mr. C. Hedley, Mr. J. H. Maiden, and Dr. J. F. Watson.

On the 10th of the same month the Centenary was also fittingly observed by a visit to Kurnell, the principal

speakers on the occasion being Sir William Cullen, the Hon. Sir Joseph Carruthers, His Honour Judge Docker, the Hon. J. Lane Mullins and myself.

As your representative I attended several meetings of the Board of Visitors of the Observatory. During the year it was my pleasure to present, on behalf of the Australasian Association for the Advancement of Science, the Mueller Memorial Medal to Mr. R. T. Baker, F.L.S., for eminent services rendered in the cause of Botany. In that capacity also I presented the Clarke Memorial Medal to Mr. R. T. Baker, F.L.S. Various social functions were attended, among which were the centenaries of the Royal Agricultural Society and of the New South Wales Branch of the British Astronomical Society.

The Annual Dinner of the Royal Society was held on April 27th, 1922. His Excellency Sir Walter Davidson, the State Governor, was the principal guest.

The success of the Society is due in great measure to the unremitting attention of your Honorary Secretaries, Mr. R. H. Cambage, F.L.S., and Professor J. A. Pollock, D.Sc., F.R.S., together with that of the Honorary Treasurer, Professor H. G. Chapman, M.D. All the members of the Society heartily appreciate their great interest in the welfare of this Society.

During the year thirty-one new ordinary members were elected, and one honorary member. Twelve resignations were accepted. There are now 375 members on the roll.

It is a matter of sincerest regret that we have lost seven members by death:—Sir John Russell French, Dr. F. H.

Since the Presidential Address was delivered the announcement has been made that the David Syme Prize for 1922 has been awarded to Mr. H. G. Smith, F.C.S., one of our Council for his great work in connection with the chemistry of the genus *Eucalyptus*.

Quaife, Mr. P. W. Rygate, Mr. J. M. Sandy, Mr. E. J. Statham, Mr. T. I. Wallas, and Mr. H. D. Walsh.

Sir JOHN RUSSELL FRENCH, K.B.E., became a member of the Royal Society in 1899, and remained with us until the time of his death, June 30th, 1921. He was born in India in 1847. His father was a major in the Indian Army who came to Australia when Sir John was only 11 years of age. Major French took up farms at Kameruka on the South Coast. Sir John Russell French was recognised throughout Australia as one of the most eminent bankers this country has possessed. It was partly in recognition of his great services, in an advisory capacity to the Commonwealth Government during the War, that he was made a Knight of the British Empire in October 1918. He was General Manager of the Bank of New South Wales from 1894 until his death. Apart from his vocation as a banker, Sir John identified himself with all the main public movements, especially those of a patriotic and philanthropic nature. He was one of the members of the Walter and Eliza Hall Trust, and he was a prominent official at St. Andrew's Cathedral of Sydney. He was a member of the Committee of the Clergy Widows' Fund. He was one of the founders of the Institute of Bankers of New South Wales. Among the many public positions which had been held by him were those of President of the Sydney Chamber of Commerce and President of the Associated Chamber of Commerce of Australia; he was also a director of the Royal Prince Alfred Hospital.

Dr. FREDERICK HARRISON QUAIFE, M.A., M.D., Master of Surgery, joined the Royal Society in 1876. He was a member of Council from 1897 until his death on the 7th March, 1922. He was a Vice-President of the Society also during the periods 1905–1909 inclusive, and from 1912 till 1916 inclusive. He was born at the Bay of Islands, New

Zealand, on the 5th January, 1841, his father being the late Rev. B. Quaife, Presbyterian Minister. Dr. Quaife came to New South Wales at the age of three years. He was one of the earliest graduates of the University of Sydney, and obtained the degree of M.A. in 1862. There was no Medical School in Sydney at that time, and he attended the lectures at the University of Glasgow, whence he obtained the degrees of M.D. and Master of Surgery in 1867. He was registered as a medical practitioner under the N.S.W. Medical Practitioners Act on the 5th January, 1869. Prior to 1880, and for many years afterwards, he practised as a physician at "Hughenden," Queen Street, Woollahra. He was one of the original members of the New South Wales Branch of the British Medical Association which was established in 1880. · He was President for the year 1884–1885. He was a member of the N.S.W. Medical Board, that is the Statutory Board under the Medical Practitioners Act of N.S.W., from 1894 to 1915. Apart from his medical practice he was an enthusiast in many branches of science and art, especially, Optics, Electricity, Astronomy, and Music. He had a laboratory at Woollahra where he conducted numerous electrical experiments, and he possessed one of the earliest Röntgen Ray apparatus in the State, which was used during the South African War. He was engaged in experimental work in Optics until the time of his death. He was an active member of the Astronomical Society, being interested especially in the spectroscopic phenomena of the stars. He was associated intimately with the advancement of Music in N. S. Wales, being a member both of the Sydney Amateur Orchestral Society and of the Royal Philharmonic Society. Dr. Quaife will be long remembered in the Royal Society by reason of his charming personality, his extreme kindness, and his benefits to this Society of a material nature. One of these, namely,

an electric lantern, is prominently before us whenever lectures delivered within our Hall are illustrated by slides. His three sons studied medicine, the eldest dying before the completion of his University course; one son, Dr. Cyril Quaife, is a specialist in mental cases in London; Dr. Thorold Quaife is an authority on tropical diseases in the Malay States.

PHILIP W. RYGATE, M.A., B.E., Assoc. M. Inst. C.E., L.S., joined the Royal Society in 1893, and was a member until the time of his death, which occurred on the 26th June, 1921, in his 58th year. Mr. Rygate was one of the leading surveyors in New South Wales. He held prominent positions in surveying and related institutions, and he was of inestimable assistance to his colleagues by reason of his sound knowledge of surveying, by his charming personality, and his power of mental detachment. He was born in the year 1862 near Bowenfels, his father being Dr. Rygate, who removed shortly afterwards to Wellington, where the family remained for many years. He was educated both at Newington College and at St. Andrew's College of the University of Sydney. While at Newington he was Captain of the First Cricket and the First Football Teams, and at the University he played with the First Football Team. He entered the Engineering School in 1883, being the first student at that institution. He obtained his degree thence as B.E. in 1885. In 1886 he won the degree of M.A. A little later he received the position of assistant to Mr. J. B. Suttor, Government Surveyor. In September 1893 he started in private practice as a surveyor in Sydney. He was in charge of many important surveys in the city and in the country, the most considerable of these being, perhaps, the Resumption Surveys rendered necessary by the Burrinjuck Reservoir Scheme. After the resignation of Mr. G. H. Knibbs from the position of Lecturer in

Surveying to the University, Mr. Rygate acted as Lecturer for a short time. This was about the year 1905. For a considerable time, terminating only at his death, he represented the Institution of Surveyors on the Surveyors Board connected with the Department of Lands. He was President of the Institution of Surveyors of New South Wales during the years 1917 – 1918.

JAMES MONTAGUE SANDY joined the Royal Society in 1919. He was born in Sydney 64 years ago, and died July 1921. He was the son of Mr. James Sandy, a former member of this Society, who in 1853, founded the business of which Mr. J. M. Sandy himself afterwards became Governing Director. He was educated at the Sydney Grammar School. He was intimately associated with many notable and philanthropic movements, especially the Y.M.C.A. and the Benevolent Society. Mr. Sandy regarded the Y.M.C.A. as one of the finest influences for good citizenship among the young men of the community, and to its advancement he devoted his time unsparingly. He was Vice-President of that institution for several years, and was its President in 1919. For twenty-two years he was a director of the Benevolent Society of N.S.W., and had been appointed to the Board in 1898, rendering most valuable services as Honorary Auditor, as a member of the House Committee, as Honorary Treasurer, and as Vice-President. He was appointed as a Life Governor of the Society in 1909, in recognition of his great services in the cause of benevolence. He has left a widow, three daughters, and two sons; the eldest son, Flight-Lieutenant J. L. Sandy was killed in France in December 1917; another son, Mr. Harold Montague Sandy, held the rank of Lieutenant on active service and was awarded the Military Cross.

EDWYN JOSEPH STATHAM, Assoc. Mem. Inst. C.E., joined the Royal Society in 1892, and was a member until his death

in August 1921, at the age of 81 years. Two papers were contributed by Mr. Statham to this Society's Proceedings. Mr. Statham was educated at the King's School, Parramatta. His earlier training there was conducted under the supervision of the Rev. R. Forrest, but later under that of Dr. Woolls. He was trained as a civil engineer by the late Mr. Bell, City Surveyor. Mr. Statham was one of the pioneer officers in the Department of Works, N. S. Wales. He was Road Superintendent at Parramatta, Goulburn, and Illawarra, the first section of the famous Bulli Pass being formed under his supervision. For many years he was Supervising Engineer for the Northern District of the State, his headquarters being at Grafton. Many trial railway survey lines from the plateau to the coast were made under his direction, particularly those from Tenterfield to Lismore, and from Armidale to Glenreagh. Mr. Statham was the oldest surviving member in this State of the Institute of Civil Engineers. He was elected an Associate Member of the Institute in 1868 and remained a member until his death 53 years later. Three sons survive their father, Mr. Claude Statham, Solicitor of Wollongong, the Rev. C. M. Statham, Rector of Christchurch, Sydney, and Mr. G. H. Statham, of the Solomon Islands.

THOMAS IRWIN WALLAS, Bacteriologist and Analyst, joined the Royal Society in 1917, and died 10th Jan., 1922.

HENRY DEANE WALSH, B.A.I. (Dublin), M. Inst. C.E. joined the Royal Society of New South Wales in 1891. He was a member of our Council for the years 1906 – 1909, inclusive, and from 1913 – 1918, inclusive. He was a Vice-President during the period 1910 – 1912, inclusive, and was our President for the year 1909. He contributed two papers on engineering subjects to this Society. He was born in Ireland and he died on August 29th, 1921, being 68 years of age. He was a son of the late John Edward Walsh, who

in 1866 was Attorney-General for Ireland and a member of Dublin University, and who was also at the time of his death Master of the Rolls for Ireland. Mr. Walsh was a graduate of the Dublin University and for some years after receiving his degree he was employed in railway and other engineering work in the United Kingdom. In 1876 he came to Australia and joined the Public Works Department. He was appointed Resident Engineer at Newcastle, and ten years later he became District Engineer of that area. In 1892 he was appointed an official member of the Hunter District Water Supply and Sewerage Board. He was President of the Board from 1896 till 1901. In the latter year he was appointed Engineer-in-Chief of the Sydney Harbour Trust. While in this position he designed and built Dalgety's Wharf at Miller's Point, and he collaborated with others in the construction of Hickson Road together with the designing and construction of Walsh's Bay and Jones' Bay. On January 1st, 1913, he was appointed a Commissioner of the Sydney Harbour Trust. Mr. Walsh was elected an Associate Member of the Institute of Civil Engineers on the 6th February, 1883, and he was made a Member on the 5th November, 1889. He was a member of the Local Advisory Committee from the 10th June, 1902, to the 14th July, 1921, at which time he resigned on account of failing health. He was chairman of the Advisory Committee from 25th October, 1907 to the 11th November, 1909. His death removes from our midst one of the foremost engineers of Australia, but our colleague's name is immortalised in the names of Walsh Island at Newcastle, and Walsh's Bay at Sydney. These names were given in recognition of his signal services to the State and in the cause of engineering. The only son of Mr. Walsh was killed at the Great War.

Dr. ROBERT LOGAN JACK, LL.D., F.G.S., M. Inst. M.M., died on the 6th November, 1921, in his 77th year. Dr. Jack was not a member of this Society, but he was a distinguished geologist to whom the Clarke Memorial Medal of this Society was awarded in 1895. The Clarke memorial Medal was given during the same year to Robert Etheridge Junior, who had collaborated with Dr. Jack in the preparation of a memorable publication dealing with the Geology of Queensland. Dr. Jack's family was a distinguished one, a brother having won the title of Senior Wrangler. Dr. Jack was born at Irvine, Ayrshire, Scotland, in 1845, and was educated at Irvine Academy, and Edinburgh University. After a service of ten years with the Scottish Geological Survey, he accepted the position of Government Geologist in Northern Queensland in 1877, and soon afterwards became the Government Geologist for the whole State. This position he resigned in 1899. During the same year he lead an expedition in Western China. On this expedition he was accompanied by his son, Mr. Lockhart Jack, Assistant Government Geologist in South Australia. Between the years 1899 and 1904 a considerable portion of his time was occupied in private practice as a consulting geologist in England, but in 1904 he was appointed by the Government of West Australia as a Royal Commissioner on the Collie coal field, and in 1911 he was appointed Chairman of the Royal Commission to investigate and report on the lung diseases to which miners are particularly susceptible. Dr. Jack was the author of a number of works including "The Mineral Wealth of Queensland" (1880), "Handbook to Queensland Geology" (1886), and "The Geology and Palæontology of Queensland and New Guinea" (1893, two vols.). The latter was written in collaboration with Robert Etheridge Junior. His latest book entitled "Northmost Australia" has been published recently in London.

A Contribution to the Hypothesis of Coral Reef Formations.

Previous Work.

The literature on coral reefs is voluminous, as considered from the time of Darwin to the present day. Vaughan[1] divides hypotheses of coral formations into three main groups.

1. *Darwin-Dana Hypothesis* [Supported by David (Funafuti) and Davis].

According to these authors corals first form a fringing reef along the shore of a subsided land area, the reef growing upward at a rate such that its upper portion remains near the surface of the water. By continued submergence the shore reef is converted into a barrier. Continued subsidence where the enclosing land area is an island may result in the production of an atoll.

2. *Semper-Murray Hypothesis.*

These authors considered that atolls could be formed in stable areas, or even those of elevation, by the solution of the limestone masses forming coral reefs and that currents and waves "can develop channels behind fringing reefs, and in that way transform a fringing reef into a barrier."

3. The Third hypothesis, as shown by Vaughan, has grown gradually from the work of many observers whose main ideas fall naturally into two types, namely, those who believe that "off-shore reefs have formed on antecedent flattish basements or platforms during or after submergence in areas where ecologic conditions are favourable for the life of reef-bearing corals," and those who consider that continental shelves, as also island shelves, have been formed by marine action during the great ice visitation of the Pleistocene Period, and that coral reefs have thriven

[1] T. Wayland Vaughan. Coral and the Formation of Coral Reefs, Annual Report Smithsonian Inst., 1917, p. 189.

on these platforms of erosion during the milder interglacial epochs of the same period.

With the first hypothesis four great names are inseparably connected, namely Darwin, Dana, David, Davis. The names are in chronological order of the period of championship of the hypothesis conducted by them.

With the second hypothesis the principal names associated appear to be Semper, Murray, Alexander Agassiz, and Stanley Gardiner.

To the second portion of the third hypothesis important contributions have been made by Vaughan, Guppy, Hill, and Mayor.

With the second division of this same idea, namely, that known as the Glacial Control Hypothesis, the name of Daly is inseparably associated.

As late as 1921 G. A. Molengraaf[1] pointed out that:—

"The deep-sea basins and the adjoining elevated islands are simultaneously formed, and continue to be developed by a process of folding at a certain depth.

The islands are elevated and grouped in rows because they are nothing but the culminating and fractured portions of submarine ridges which rise up on top of the anticlinal portions of the deep-seated folds.

The trend of each row of islands roughly indicates the line of strike of the anticlinal axis of each of these folds.

The deep-sea basins are elongated more or less exactly parallel to the adjoining rows of islands, because they are formed above the subsiding synclinal portions of the deep seated folds.

All the islands are, as a rule, upheaved, but the upheaval has been very unequal, as can be observed if the islands are compared one with another, or if a comparative examination be made of

[1] Modern Deep Sea Research in the East Indian Archipelago. Geographical Journal, Vol. 57, 1921, p. 116.

different portions of one island. In exceptional cases the upheaval is wanting, and even subsidence may occur instead, as has been explained above.

The consecutive phases of development of the anticlinal portions of the folds are revealed at the surface by the mode of development of the reefs, and can be studied by comparing the character and the relative position of extinct reefs of the same age."

Darwin's conception of coral growth during subsidence of the basins of both Pacific and Indian Oceans was captivating in its simplicity and found ready champions in the authors named above, namely, Dana, David,[1] and Davis.

David's ideas are crystallised partly in his classic monograph on Funafuti and in the exquisite model, to scale, of the atoll even to its base at the points of confluence with the Pacific Ocean floor.

Davis considers the islands and lands associated with coral reefs as so many silent witnesses of the great coral drama being enacted within the tropic seas, and he seeks to decipher the history of coral growth from the evidence of their written but unspoken testimony. His conclusion is that the coral reefs of the Pacific have been formed during periods of submergence of the various islands of the Pacific. On the other hand he establishes his point that each island has had an individual structural history.

These studies of Davis, illustrated by block diagrams, form one of the most valuable contributions to our knowledge of the Pacific Islands, and his explanations of "plunging cliffs," the variable heights of associated coral islands, of atolls associated with embayed islands, forming the centre of the lagoons in certain cases, as of dissected volcanoes, have assisted in a marked manner in the elucidation of the coral reef problem.

[1] These remarks apply only to David's published views of Funafuti.

Other noted workers, while admitting the general idea of coral growths upon areas undergoing submergence, have differed in certain particulars from the conclusions of the four illustrious authors mentioned above.

Thus Vaughan, by long and patient but brilliant experiments and observation, has collected a veritable array of facts of the utmost importance in connection with the growth of coral reefs on platforms of erosion. His article, quoted in a previous paragraph, is invaluable to all modern workers interested in coral reefs.

Daly's contribution to the problem is also memorable, and no explanation of coral reef origins could be considered complete, which should neglect the fact repeated by him, namely, that both the Pleistocene coral reefs and the recent glacial period were controlled in a great measure by the opposed phases of one common agency, or which should neglect the fact that the sea level rose with each interglacial period and fell with each advance of the ice sheets.

Hedley and Taylor, Wood-Jones, Mayor, and Vaughan, have worked in other ways again.

Hedley and Taylor[1] have shown that coral reefs grow in crescentic curves with their convexities directed against the general motion of the prevailing wind.

Mayor,[2] Vaughan,[3] and Wood-Jones,[4] have demonstrated conclusively, the marvellously rapid growth of coral, by patient and skilled experiments conducted within modern coral reefs.

[1] Coral Reefs of the Great Barrier, Queensland, by C. Hedley and T. Griffith Taylor, Aus. Assoc. Ad. Sc., Vol. XI, 397 (1907).

[2] A. G. Mayor, Ecology of the Murray Island Coral Reef. Carnegie Institute, Wash. D.C., 1918. [3] Vaughan, *Ibid.* [4] F. Wood-Jones, Coral Reefs and Atolls, Lowell, Reeve and Co., London, 1912.

The Present Structure of the Pacific.

In this contribution to the growing literature of coral reefs it would be advisable, perhaps, to consider the general framework of the Pacific Region, together with brief references to the West Indies and to the Indian Ocean before considering the origin of coral reefs themselves.

Geographical Unity of the Pacific.

A geographical unit may be defined as a portion of the earth's crust in which the formation of the major topographical features has been controlled by one agency. This agency may be considered as operating similarly within and around the whole area.

Assuming for the present that the Pacific Region is a geographical unit, the controlling agency in its formation appears to have asserted itself periodically from early geologic time, the successive periods of which, when considered together, are characterised by the production of varied but related forms. These were similar in general shape and were situated similarly with respect to a great central feature, but the quantitative effect of the periodic control mentioned varied during the successive periods of its application.

The controlling agency which determined the geographical unity of the region under consideration appears to be related in some way to the sagging of the great suboceanic mass under its own weight and with the consequent "creep," by undulations, of the bordering continents towards the low-lying block constituting the Eastern or Main Pacific.

Evidence of Unity.

Adverting to the consideration of the statement above as to the geographical unity of the region under discussion, it will be found advisable to consider a few of the main features

whose existence is believed to support this inference:—

(*a*) The arrangement of the "ocean deeps" or trenches.
(*b*) The distribution of the main earthquake zones.
(*c*) The distribution of the principal volcanic belts.
(*d*) The distribution of the "island arcs" and plateaus.
(*e*) The form of the floor of the Pacific.
(*f*) The nature, distribution, and variable movements, of Kainozoic coralline limestones and of coral reefs within the Greater Pacific.

The most impressive feature, suggested at first glance, concerning the first group of four of the above is their arrangement as broken, or discontinuous, girdles, of the Pacific. A feature almost equally impressive also is the great interference with these Pacific girdles by an outside but similar set, which we may call the Tethyan girdle, the individuals of which are arranged mainly in the north tropical and subtropical zones.

(a) *Zone of Deeps.*—The "ocean deeps" or trenches are arranged parallel or subparallel to the main trend of the land masses nearest to them, which in turn, have a trend sympathising in the main with that of the nearest continental coast.

Beginning with the Chilian area, and proceeding thence northward and returning by way of the Western Pacific and Antarctic, the order of their occurrence in space is the Hæckel, Richards, Bartholomew, Krummel, Milne-Edwards, Maury, Supan, Tuscarora, Challenger with Nero, Pelew, Philippine, Planet, Tongan, and Kermadec, Deeps.

These deeps follow the west coast of South America and of Alaska closely, as also the eastern coast of Japan. In the Caroline, Marianne, Ladrone, and Philippine Groups, the Ocean Trenches are not collinear, but are arranged *en echelon* alternating with land crests which are dotted with islands, the latter being arranged linearly; thence by

way of New Britain and New Ireland,[1] Samoa, Tonga, and far to the east of New Zealand, beyond which, to the south, the Pacific has not been proved as yet to contain Ocean Trenches.

This belt of deeps marks the margin of the Eastern or Main Pacific Ocean. The Tasman Sea which separates Australia from New Zealand, is a deep bay or inlet of the Pacific, and is, moreover, of great geological antiquity.[2] Of these, all the greatest deeps are confined to the western side of the Pacific, and no "trench" is known to exist in the portion of the ocean lying between latitude 35 degrees South and Antarctica.

(b) *Zone of Earthquakes.*—Zones of maximum earthquake phenomena are arranged immediately on the inward, or continental, side of the Ocean Deeps. The Tethyan interference is a noticeable feature in this connection and in the case of the Ocean Deeps.

This zone appears to pass through the great "deeps" of the Hæckel-Milne Edwards Group, thence along the coastal strip from Honduras to Alaska. To the south of Alaska and the Aleutian Islands it broadens and passes through the island arcs of the Western Pacific to New Zealand.

The great Tethyan girdle of earthquakes forms an interference with the Pacific girdle, the ocean trenches following the outer edge of these zones where they are confluent. F. Omori's work[3] is of great assistance in this connection.

(c) *Volcanic Rings or Belts.*—Volcanoes are developed in the same great region as the "ocean trenches" and the main earthquake zones, but they lie within rings situated

[1] The Planet Deep (30,000 feet) here lies on the concave or inner aspect of the Island and not on the convex or outer one.

[2] E. C. Andrews. Structural Relations of Australia and New Zealand. Journal of Geology, 1916.

[3] Bull, Imp. Earthq. Inst. Commission, Vol. I, 1907, Tokyo, Japan.

a little closer to the continental masses than the earthquake zones.

These volcanic belts fall naturally into two divisions namely, those which are dormant and those which are active. In general the dormant members lie farther from the trenches than the active ones. Recurrence is made to this point at another place. Both types are confined to the Pleistocene Period.

(d) *The Plateau Rings and "Island Arcs."*—The Eastern Pacific, from Alaska to Patagonia, is bordered by high plateaus, arranged in belts both parallel and subparallel to the coast and separated from each other by tectonic valleys. Examples of these great highland belts are the Andes, the Cascades, the Selkirks, the Rockies, and the various Sierras.

The Western Pacific is bordered by belts of continental plateau and interplateau valleys similar in disposition to those of the Cordillera of Western America, the quantitative factor, however, being less pronounced in the case of the former. The real counterparts of the American cordillera must be sought in the more marginal portions of the Western Pacific Basin itself. These western homologues include Japan, the Carolines, Ladrones, Mariannes, Philippines, New Guinea, Solomons, New Hebrides, New Caledonia, New Zealand, Fiji, Tonga, and Samoa, together with their distant outliers, such as the Hawaiian, Cook, Society, and Paumotu Groups. The deep-sea troughs lying parallel to these groups are the counterparts of the intermontane valleys of the Cordillera, and the deep seas which break the continuity of the island orientation are the exaggerated counterparts of the radial warpings and faultings of the syntactic arcs of the cordilleran regions. The main island arcs are, in reality, plateaus, or elevated plains, of erosion. The valleys which ornament them in places appear to be

features which are insequent or accidental, to the main topographic forms.

The ages of all the plateaus fall within two periods, namely, the closing Kainozoic for the main continental range and the larger islands, while their smaller satellitic groups of islands, together with certain portions of the coast range of Western America, appear to be of Pleistocene age. This point is discussed elsewhere.

(e) *The Floor of the Pacific.*—From the foregoing it is evident that the Pacific Basin admits readily of division into two related units, the one lying easterly from the other, and each being arranged subparallel to the main trend of the nearest bordering continent. The eastern member contains a few prominent island groups such as the Hawaiian, Society, Marquesas, Paumotu, Cook, Marshall, Ellice, and Gilbert, Groups. The floor of this portion is of great average depth, almost like a vast submarine plain. The great "ocean trenches" lie within its margin and their orientation conforms to that of the nearest surrounding land. Its area is 40,000,000 square miles approximately. As a structure it is relatively stable. This may be called the true Pacific.

The western member is of less area and its floor is diversified with sea trenches, volcanic belts, and island plateaus, arranged in arcuate form and separated from each other by deep seas. The area is one of great instability when considered in belts. This is discussed in another portion of the report.

The South Western Pacific.

In order to comprehend the relation between coral reef growths, and the structure of the Pacific, in Kainozoic time, it may be advisable to consider one division of the Pacific as a type of the whole. In this connection it would be

profitable to consider the division in which Australia occurs, namely, the south western portion, inasmuch as it falls properly within the Australian sphere.

It is here proposed to mention merely the general arrangement of the main topographical features together with their age.

(1) *Disposal of Topographical Forms.*—The main topographical features of the region under discussion have an orderly arrangement, considered from the south west of Australia both to the Society Islands and to Micronesia.

South Western Australia consists of a low and uniform plateau of great area[1] rising to a height of 2000 to 4000 feet to the north and the north-east. The surface of this great plateau is regular and not broken by important radial gaps of a structural origin.

The vast area lying between the Western Australian and the Eastern Australian plateaus consists of two well marked portions, namely, a western one of plains diversified by high and narrow plateau belts with warped and faulted margins, and an eastern one comprising the plains overlying the great Australian Artesian Basin (650,000 square miles), and the Riverina, together with the Victorian Basin. The general trend of these features is curvilinear and subparallel to the plateaus associated with them to the East and West.

The eastern margin of Australia forms another great geographical unit, in the shape of a plateau which is relatively narrow and high as compared with the Western Australian form and which is broken by low tectonic gaps arranged radially from a broad centre in South Western Australia. Bass' Straits is the most pronounced of these

[1] Jutson, J. T. Physiography of Western Australia, Geol. Sur. W.A., 1917.

gaps. Other shallow structural valleys occur within the plateaus and are arranged meridionally producing an undulatory appearance in some of the highland areas.

The ring of sea troughs, such as the Tasman, Coral, and Arafura Seas, marks the first great outer division of the Australasian structures. Within these a few lines of low islets are arranged subparallel to the Australian coast. These islet rings appear to be the structural counterparts of the faulted and warped blocks of Central Australia.

Other belts of islands with interinsular seas are represented by New Zealand and its related groups. Two great structural lines, or zones, appear to run through the North Island, one passing through the northern extremity toward the islands lying to the north-west and the north-north-west, and one passing to the north-north-east towards the Kermadecs and Tonga.

New Guinea, the Solomons, New Caledonia, and New Zealand, form the base of a great island knot which has its north-eastern extremity in Samoa. The individual island loops of this knot appear to be separated from each other within the central portions but are continental and confluent, at the southern and western extremities. The knot itself would appear to arise as the result of the mutual interference of the Pacific and Tethyan controls mentioned above. This feature may be called the Great Southern Pacific Knot.

The Gilbert, Cook, Society, and Paumotu, Groups, form other belts of the same series.

These island arcs or plateaus, measured from the individual and associated ocean trenches as datum bases, are higher than the eastern Australian plateaus. Moreover, the individual island belts are separated from others along the same cuspated zone by deep seas arranged along radial lines extended from South Western Australia.

All of these Pacific elements, inclusive of Western, Central, and Eastern Australia, the Tasman and Coral Seas, of New Zealand with the great Pacific Knot, the Aldrich Deep, and the outer belts of islands and sea troughs, comprise several important earth waves whose crests are represented by the plateaus and submarine ridges and whose troughs are represented both by land valleys and ocean bases. All are of the same age if they are considered as groups and not as individual islands thereof.

These earth waves reveal the influence of progressive instability from South Australia to the Aldrich Deep.

Similarity of External Structure in Individual Island Groups.

For the purpose of simplicity it would be advisable to supply a few additional details of structure for several types of the Pacific groups of islands.

The types selected for description are:—

a_1 Australia.
a_2 New Zealand.
a_3 New Caledonia.
a_4 The Greater Solomons.
a_5 Fiji.
a_6 Tonga.
a_7 Society with Paumotu Group.

a_1 *Australia.*—The plateaus of Australia are the revivals of a series of the crests of earth undulations or waves which date from the early Kainozoic at least, beginning at that time as forms of slight relief, only they have been worn down, and raised successively from the plains to the plateau stage. The present highlands or plateaus, are the algebraic sum of the warping movements attendant on the Kosciusko, or closing Kainozoic Period. The uplifts have been gradual and vibratory, with pauses of stable equi-

librium. The deep dissection of the present plateaus has been accomplished mainly during the Pleistocene.

A continental shelf of variable width encircles the whole of Australia with the exception of the Queensland coastal area where its place is taken by the Great Barrier Reef of Australia.

No "soapstone" beds of Tertiary Age occur in elevated positions within Australia, neither are coral reefs of Pleistocene Age found elevated more than a few feet above sea level within this great land block.

The axis of elevation in Eastern Australia during Tertiary time appears to have moved to the east slightly as successive waves, or undulations. The continent has been stable during the Pleistocene Period itself.

a_2 *New Zealand.*—This complex land block consists of a series of syntactic arcs of mountainous nature associated with tectonic valleys. The Pleistocene volcanoes of the western half appear to be quiescent, but active intermittent types lie somewhat to the east of a line passing to the east of Taupo and thence to the east of the Bay of Plenty and towards Tonga. Arcs through New Guinea and Tonga appear to become confluent in New Zealand. Cotton[1] has described this area as a series of fault blocks.

It is possible that the late Tertiary and early Pleistocene gravels of the deeper tectonic valleys will be found to be warped and faulted along their margins, a phenomenon to be expected by reason of the uplift and creep of the undulating land crests which form the high plateaus.

a_3 *New Caledonia.*—This island has its larger axis arranged subparallel to the Australian coast in the vicinity. A large Barrier Reef surrounds the island. No elevated

[1] Cotton C. A. The Structure and Later Geological History of New Zealand, Geol. Mag. 1916, p. 243.

coral reefs of Pleistocene Age have been recorded from New Caledonia itself.

The Loyalty Islands, inclusive of Walpole Island, form a subparallel series lying to the east of the mainland being separated therefrom by a sea trough. Davis has shown that the islands Mare, Lifu, and Uvea, are composed of coral limestone of Pleistocene Age and that one at least shows the evidence of pronounced tilting.

Walpole Island shows five lines[1] of marine erosion on its cliffs of elevated coral. This suggests then that New Caledonia has been in a condition of stable equilibrium during the greater part of the Pleistocene Period and that a great barrier reef has grown on the platform as in the case of the still more important barrier reef of Eastern Australia or that it has grown on a submarine coast of undulating type.

The Loyalties, together with Walpole Island, appear to have formed unstable units as compared with the main western block of New Caledonia and they show the evidence of warping, the islands forming the crest of a land wave while the corresponding troughs lie east and west of this island-dotted crest.

a_4 *The Greater Solomons.*—These consist of a great double line of volcanic islands. The Kainozoic beds of "soapstone" lie unconformably upon them.[2] These in turn have been folded or warped and upon their eroded surfaces coral reefs of Pleistocene Age and of non-bedded and amorphous type lie unconformably in turn.

Guppy has recorded raised reefs of Pleistocene Age at heights as great as 1000 feet above sea level within the Solomons themselves. Active volcanoes occur in the group.

[1] Seen in photographs taken by Messrs. Danvers Power and A. C. Mackay.

[2] Guppy, H. B. The Solomon Islands. Swann, Sonnenshein, London, 1887.

A series of coral reefs with associated atolls lies on a near and subparallel arc extending beyond not only the group under discussion but also beyond the New Britain Group. This indicates a geographical unity for the Solomons, New Britain, New Ireland, and the New Hebrides.

a_5 *The Fiji Islands* consist of four main belts, namely (aa) the western or larger islands of Viti Levu and Vanua Levu, (bb) the extinct and dissected volcanic masses lying immediately to the east and extending from Taviuni to Kandavu, (cc) the raised coral reefs of Lau or Eastern Fiji, (dd) the outlying atolls of Eastern Fiji.

These belts converge to the north. The eastern member which is composed of raised reefs and atolls is longer than the belt of the main western islands. This is a feature common to the island groups.

(aa) The large western islands have nuclei of old rocks.[1]

The Kainozoic deposits which overlie these older rock types are bedded and have been subjected to folding. The principal types included are "soapstone," well bedded limestones containing corals, and volcanic material. These apparently are of Miocene Age.

A great barrier reef surrounds the main islands of Viti Levu and Vanua Levu.

Elevated coral reefs of Pleistocene Age, however, have not been recorded from heights more than a few feet above sea level.

The marked dissimilarity which exists between the coral-bearing limestones of Tertiary Age and the Pleistocene coral reefs is discussed below. The absence of Pleistocene coral reefs from the continental masses and the large western islands of the individual groups of islands is discussed elsewhere also.

[1] Woolnough, W. G. The Continental Origin of Fiji. Proc. Linn. Soc. of N.S Wales, 1903.

(bb) The broad zone containing sporadic volcanic masses of recent age includes Taviuni, Gau, Kandavu, Totoya, Moala, and other well known islands, which rise from moderate depths.

(cc) The raised coral reefs of Lau[1] lie to the east of this zone of recent vulcanism.

The island types of this belt are terraced and the elevated coral reefs thereof occur at altitudes varying from 50 to 1030 feet above sea level.

The limestone composing these raised reefs is amorphous and lacks any sign of bedding. Each form is Pleistocene in age. These limestones overlie beds of Kainozoic limestone, "soapstone" and volcanic conglomerate, in an unconformable manner. The "soapstone" and limestone beds which form the basement in part, show variable dips, and have a general resemblance to the Kainozoic beds of west or stable Fiji. The coral reefs of Pleistocene Age, on the other hand, are composed of limestone which is homogeneous throughout and rings under the hammer.

(dd) The eastern belt of atolls to which Davis[2] has drawn attention is composed of limestones similar in all respects to those of the raised reefs of Lau. Beyond these atolls to the east lies the deep ocean.

a_6 *Tonga.*—The Tongan Region or Group admits of a threefold division—

(aa) A western line of volcanoes.

(bb) A wide and associated zone of coral reefs and of atolls.

(cc) An "ocean trench" of profound depth.

[1] Lau signifies "east."

[2] Davis, W. M. The Islands and Coral Reefs of Fiji, Geogr. Journ., London, 1919.

Taking the western zone as a datum, the remaining groups lie to the east thereof in the order of description here observed.

These belts are parallel or subparallel to each other. The volcanoes may be dormant as Laté, or active as Kao. They rise as isolated cones from moderate sea depths.

Tonga proper consists of very large plains and terraces of coral reefs, rising from a few feet to 1050 feet above sea level. The profound sea depth known as the Tongan Trench forms the lowest portion of the compound earth-wave forming the group.

a_7 *Society and Paumotu Groups.*—The Society Islands consist of a series of volcanoes, which are arranged along an arc whose curve is sympathetic with the main trend of the Tongan, and other associated groups. These volcanoes are encircled by coral reefs, but no elevated reefs have been recorded therefrom.

The Paumotus, or Low Archipelago, represent a group of elevated coral limestones and of atolls lying along a great land-wave crest related structurally to the volcanoes of the Society Group. The Cook Group is a similar but less impressive example of this type.

(f) *Important Geological Features Connected with the General Geology of these Island Groups.*—There are at least six important features to which attention may be drawn at this stage of the discussion.

(1) The variations in the Tertiary and Pleistocene limestones.

(2) The variable heights to which limestones belonging to these two periods occur in the various belts of the individual island groups.

(3) Variable structures composing the individual groups.

(4) The relative stability of the belts comprising the individual groups.

(5) The relative stability of the island groups compared one with the other as from Australia to the Paumotus.

(6) The nature of these structures of the South Western Pacific.

(1) *The variable nature of the limestones.*—The observer is always impressed, not only with the amorphous and dense nature of the younger or Pleistocene reefs, but with their evident lack of bedding planes. Cliffs of this limestone occur which are many hundreds of feet in height but which reveal no sign of bedding within them.

The limestone may be full of corals and shells, as in the case of the Liku of Vavau (Tonga), or it may be dense and ringing under the hammer, or weathered into Karrenfelder, or into harsh needles and pinnacles.

The older or Tertiary limestones may contain corals and shells, or they may be granular and of warm tints, such as those underlying the Pleistocene reefs at Qila Qila (Fiji). In every case, however, they are well bedded and are totally unlike the coral reefs of the Pleistocene in general appearance. They are intimately associated also with bedded "soapstones."[1]

(2). *Heights of Elevated Limestones.*—The coral reefs of Pleistocene Age do not occur in elevated form on the western belts of the individual groups, except in a couple of instances, such as the Solomons and the New Hebrides, where great interference of earth waves is manifest.

Thus Australia and New Caledonia have enormous barrier reefs, but no reefs of Pleistocene Age in these places are

[1] Andrews, E. C. The Limestones of Lau, Fiji. Bull. Mus. Comp. Zool. Harvard, 1900. See Plates.

elevated more than a few feet above sea level. The less stable volcanic belts of the Society and Tongan Groups possess barriers of moderate size, but no elevated reefs.

Eastern Australia has no raised reefs either of Tertiary or Pleistocene Age. Western, or Main Fiji, however, has a great development of "soapstone" and coral-bearing limestone of Tertiary Age at high elevations, all the types being well bedded.

On the other hand the long lines of coral islands which form the eastern belts of the various groups show terraced forms, the formations themselves being of coral of Pleistocene Age, but the elevations of the terraces are very variable, even in islands situated near each other. These non-bedded limestones lie unconformably on "soapstone" Kainozoic limestone or volcanic material, in beds.

(3) *The Variable Ages of the Structures of Individual Groups.*—These groups, considered from South Western Australia to Tonga, appear to show progressive youth of formation. Thence to the Paumotus they reveal a decided similarity to Tonga in structure.

Western Australia is a plain excavated in Archæozoic rocks and which has been uplifted since as a broad flat crest to an earth wave.

Eastern Australia is the crest of another earth wave which has been formed within rocks, not of Archæozoic type, but of those dating from the earliest Palæozoic to the Kainozoic.

New Caledonia is an "oldermass," as Davis would say, nevertheless much younger than its western relatives mentioned above.

The Loyalties are Pleistocene islands of small size which have emerged from the sea as gentle elevations only.

Fiji is an oldermass associated on the east with Pleistocene volcanics and with young coral reefs elevated differentially, and bounded to the north-east by ocean depths.

The Solomons, together with New Britain and New Ireland, the New Hebrides, and South-eastern New Guinea, form a complete and similar group, but earth wave interferences have formed ocean trenches within this group so that their formation is not quite so simple, although it is similar to those described in the previous paragraphs. Within them, however, may be observed the unconformable capping of the terraced reefs of Pleistocene age, on an eroded surface of bedded "soapstone." This again appears to overlie volcanic material unconformably. This is well shown in Guppy's sections[1] where the raised limestones of Pleistocene Age show the influence of tilting, or of undulatory movement, as well as of direct elevation.

(4) *The relative stability of the individual subparallel zones or belts, comprising the groups.*—Two groups are selected as types for this purpose, namely, Fiji, and Tonga.

The main islands of Fiji, namely, Viti Levu and Vanua Levu, possess folded limestones and "soapstone" beds, of Kainozoic Age, but they possess little or no trace of raised corals of Pleistocene Age. These islands are surrounded by large barrier reefs.

From this it is inferred that these land masses have been fairly stable during later Pleistocene time, with the implication thus of marine erosion which has been long continued. To the immediate east of this incurved belt lie a few raised reefs of Pleistocene Age in the form of terraces. The island members of the volcanic zone to the east, which have

[1] Guppy, The Solomon Islands. Swann, Sonnenshein, 1887, pl. 2.

been described in a previous paragraph, possess no raised reefs.

Lau, or eastern Fiji, is an unstable area and shows successive terraces of raised reefs of Pleistocene Age. If it be considered as a unit it has the form of an earth undulation whose highest point is at Vatu Vara in the centre, and which pitches thence north and south as well as east and west. The atolls lying on the subparallel zone to the east indicate the marked influence of the easterly pitch of the earth wave.

Tonga.—The volcanoes which form the western zone of the group appear to rise from a submarine platform of moderate depth. This is unstable as compared with the western line of Fiji, New Caledonia, Eastern Australia, and Western Australia, and is of recent growth. The belt of elevated coral reefs known as Vavau, Haapi, Namuka, and Tongatabu, is of Pleistocene Age and lies within a very unstable area, the southern and the northern extremities being elevated in much greater degree than the central portions. The atolls of the Tonga Group lie in the centre and in the westerly portion of this long wide zone. This is in decided contrast with the internal arrangement of Lau in Fiji.

(5) *The Relative Stability of the Individual Groups considered progressively in space from Australia to the Paumotus.*—Australia is the oldest and most stable block. It is, moreover, the block which has been stable during a greater period of time than the eastern groups. Furthermore the western portion is more stable than the eastern.

A fine example of a continental shelf has been developed around the continent.

New Caledonia, with the Loyalties, forms a group of less stability than Australia. New Caledonia, however, appears

to have been stable during the greater portion of the Pleistocene, and this implies also the decided influence of marine erosion which has been long continued. The Loyalties show a moderate amount of movement in the late Pleistocene.

New Zealand consists of convergent and syntactic arcs analogous with the island groups considered here.

Fiji is a group which has been less stable than New Caledonia during the Kainozoic. Lau or eastern Fiji, indicates a vibratory movement in the later Pleistocene in the form of undulations.

Tonga, as also the Society Islands with the Paumotus, is less stable than Fiji with variable and recent movement.

The Greater Solomons.—These may be classed as compromises between the Fiji and the Tonga Groups. Both lie in the great Pacific Knot, and near the true Pacific margin.

(6) *The Nature of these Island Structures.*—During the whole of the Kainozoic period there appears to have been a flowage or creep of the south western Pacific region towards the north east and the east, that is towards the Main Pacific basin. If the existence of the ocean waters be ignored, the earth's surface, in the region under discussion, appears to pass in compound undulations or land waves, towards the eastern Pacific. These rings or undulations are broken along their strike and are progressively narrower and more separated if traced in radial directions from West Australia to the eastern edge of the Tasman and Coral Seas. The algebraic sum of the transference of matter during the oscillations forwards and backwards, as well as upwards and downwards, appears to be towards the Pacific, but the main movement is really that of waves with the production thereby of land crests and of troughs mutually

supporting, the translatory movement of matter being very slight.

With the periodical revival of wave movement[1] the western areas have gradually adjusted their opposing forces whereas in the eastern and less stable earth waves the zone of rock flowage has provided facilities for establishing connection between the greater depth of the crust and the surface.

The main undulations under consideration rise to very variable heights and are thus discontinuous along their crests so far as the general ocean elevation is concerned. They are, moreover, divided into secondary groups, each of which tends to reproduce within itself the phenomena of increasing instability of form with progressive distance from the western zone. Examples of this action are Fiji and Tonga which tend to produce within themselves an epitome of the great earth wave series from the Leeuwin to the Tongan Trench.

Application of Foregoing.

With the evidence adduced above it is permissible, perhaps, to infer the origin of the coral reefs of the Pacific. The other great coral reef areas of the world may be explained in a similar manner. Thus from Vaughan's clear sighted observations it would appear that the Antillean area is, from a structural point of view, a bay of the Pacific region, a concave curve connecting the great convexities of North and South America along the same continuous structural line of Kainozoic Age. The Indian Ocean types, both geographically and geologically, are similar also to those of the Pacific.

The Tertiary limestones which contain corals have been deposited as beds in areas of subsidence which, in turn, lie

[1] This has proceeded periodically since Archæozoic time.

principally to the east of land blocks, such as Australia, New Caledonia, and Western Fiji. Beds of volcanic material were formed in the shallow water while in the deeper and clearer water which lies further from the land, beds of "soapstone" were formed, and with these the bedded limestones mentioned above are sandwiched in places.

The movements, which were accompanied and followed by the deposition of bedded "soapstone" and limestone, were of the nature of earth waves whose crests formed plateaus with warped margins and whose troughs formed zones of subsidence. From the waste of the land crests formed thus, the beds under discussion were derived in great measure.

In a later division of the Tertiary period this formation of land waves was revived, and as a result of the movement the denuded areas were elevated in part and submerged also in part. The eastern portions of the main island group were elevated also. Folding and warping accompanied the elevations and depressions.

The main continental mass, together with the larger islands under discussion, has remained in a condition of relative stability since that date. Denudation by streams, and the formation of continental and island platforms by marine action, have been conspicuous around land masses such as Australia, New Caledonia, New Zealand, and Fiji.

The eastern belts, together with the less stable masses, such as the Greater Solomons were denuded in great measure also.

At a subsequent date the less stable groups, such as those mentioned in a previous paragraph, also Lau (Eastern Fiji), the Loyalties (Eastern New Caledonia Group), the

Society Islands with the Paumotus, and Tonga, were again affected by the revival of the formation of earth waves. The movement was vibratory and undulatory. The algebraic sum resulted in pronounced subsidence.

By this action the groups under discussion were separated by sea troughs from the more stable blocks to the west.

Coral reefs grew upon these sinking areas and formed terraces thereon. The vertical distance between any two terraces on a given island is a measure of the amount of submergence during the particular vibration of undulatory movement of the earth wave at that stage. Inasmuch as these sinking islands were isolated from the land areas, and were formed in clear water, they were not bedded but assumed instead an amorphous and dense form showing a high content of lime carbonate, without notable admixture of foreign material, such as silicates; excepting such organisms living on the reefs, which secreted silica in their tests or shells.

During a revival of movement within the later Pleistocene the more stable blocks of the western portion of individual groups were not affected, but in the eastern islands of the groups the axes of uplift appear to have moved slightly so much so that the coral reefs which had been formed as terraces during submergence, were converted at this later stage into elevated terraces mainly of emergence and in a minor degree only of erosion. This movement of elevation was also vibratory and undulatory, as recorded by the lines of marine erosion which occur at variable heights on the associated islands, and which mark the positions of stable equilibrium during uplift.

Vatu Lele has five lines of marine erosion within a vertical height of 50 feet above sea level, whereas Vata Vara, in the same group, possesses several such lines only, and these are distributed within a vertical height of 1030 feet.

As one island strip was elevated so a parallel one within the same group was depressed proportionately. In this way, during the upward growth of the amorphous reefs, the atoll formations were formed which are associated with the elevated reefs.

The unconformable bases of these later and non-bedded types of Pleistocene reefs, together with their coastal profiles, the original forms of which are discernible still with ease, indicate the growth of the elevated reefs of Tonga, Lau, and other groups, during subsidence. The action of submergence, unaccompanied by land subsidence is discussed below.

The last movement of pronounced elevation is old, from the historical point of view, inasmuch as important barrier reefs have been formed around the islands since this date.

The pauses in the general movement of undulatory uplift were of short duration only, and are indicated by the narrow benches and parallel lines of marine erosion.[1]

It would be advisable at this stage to note the history of the western blocks of each main island group during the period that the eastern portions were sinking to receive their terraced caps of coral, and reëmerging later in undulatory and vibratory manner.

It will be remembered that the Pleistocene period was one not alone of coral reef formation, but one also of marked glaciation, as Daly has shown so well. The formation of each great ice cap belonging to the Pleistocene was accompanied by a lowering of the ocean surface possibly to the extent of 150 to 250 feet, and, at later stages, each

[1] Agassiz, A. Pacific Coral Reefs, Mem. Mus. Comp. Zool., Harvard, 1903, Plates. Andrews, E. C. The Limestones of Fiji, Bull. Mus. Com. Zool., Harvard, 1900, Plates.

great interglacial period was accompanied by an unlocking of water from the ice caps and a return of the water to the sea which gave it to them. Not only so, but Daly has reminded us also that this periodic lowering of ocean level was accompanied by a relative refrigeration of cosmopolitan influence, and that each recession of the ice caps was associated with milder periods, and therefore with a relative revival of luxuriance of coral growth which had been materially checked by the formation of the great ice cap preceding it.

During the Pleistocene, therefore, the stable blocks, such as Australia, were subjected to the action of storms, waves, and currents, which resulted in the development thus of continental and island shelves. During the interglacial period these platforms were submerged slowly by the rising sea and were covered by coral reefs associated with submergence. The corals themselves could not approach the continental areas too closely because of the mud brought down by streams in times of flood.

The last great ice cap belonging to the Pleistocene period has now returned its water content, in the main, to the sea, and the level of the great oceans has risen thus and submerged the old shelves of erosion. In these warmer waters, which have submerged the shelves very gradually, coral reefs have grown luxuriantly to form the Great Barrier Reefs of Australia, New Caledonia, New Guinea, and Fiji.

Is the effect of this recent refrigeration indicated on the unstable islets lying to the east of the Greater Solomons, New Caledonia, Fiji and other island groups?

In answer it may be pointed out that the coral reef platforms and the raised atolls, of Fiji, Tonga, and other groups

indicate strongly that at times, during submergence, the corals grew luxuriantly. The lines of marine erosion, and the narrow benches of erosion on the raised reefs themselves, as seen so well on Makatea, Vatu Lele, and Walpole Island, suggest most strongly that coral growths were checked, during the last great vibratory elevation or warping of the island, and that this corresponds, apparently, with a period or with periods of cold.

Summary.

Corals grew in the Pacific during Tertiary and Pleistocene time, and they appear to have been formed on sinking surfaces of erosion.

The Tertiary forms are well bedded and are those of transportation in the main. They are not typical coral reefs, but were formed with the outwash, within tectonic troughs, of associated highlands. These troughs were relatively shallow.

The Pleistocene types are not bedded and are due to the growth of coral *in situ* on sinking surfaces of erosion in clear water.

These Pleistocene reefs were developed mainly to the east of the more stable islands and they were elevated in part at a later date, to form raised coral reefs, while other portions sank progressively and became large atolls.

While the smaller islands were moving upward and downward in the form of undulations, the larger islands forming the west of each main group were in stable equilibrium and wide benches or platforms of marine erosion were formed around them.

A recent submergence of the whole of the Pacific area to the extent of 200 feet approximately, allowed the formation of great fringing reefs to the smaller islands, and of

great barrier reefs on the platforms of the larger stable blocks.

This brief statement indicates how accurate an index to the Tertiary and Pleistocene movements, within the Pacific region, the coral formations themselves have been. It would be extremely advisable, on that account, to make a careful examination of various typical groups of the coral area, such as Fiji, Tonga, the Greater Solomons, New Guinea, and New Caledonia, as a prelude to a detailed study of the structural forms of the Pacific in Kainozoic time.

THE POSITION OF THE DOUBLE LINKAGE IN PIPERITONE, PART II,

WITH NOTES ON SOME OF ITS DERIVATIVES.

By A. R. PENFOLD, F.C.S.

[*Read before the Royal Society of N. S. Wales, June 7, 1922.*]

IN a Part I communication read before the Society on 3rd August 1921,[1] the writer submitted evidence which showed piperitone to possess the structure of a $\triangle_1$-Menthenone-3, as diosphenol was one of the products resulting from its oxidation by means of potassium permanganate solution. As promised at the time, the examination of the acid bodies separated from the products of oxidation having since been completed, it was deemed advisable to publish the concluding evidence. As shown under "Experimental," the results confirm the aforementioned structure for this ketone.

Since the preliminary communication referred to above, two other papers have appeared bearing upon its structure, viz:—"Piperitone, Part I. The occurrence, isolation, and characterisation of Piperitone," by John Read and Henry George Smith, Journal of the Chemical Society, June 1921, page 779, and "The Essential Oil from *Andropogon iwarancusa*, Jones, and the Constitution of Piperitone," by John Lionel Simonsen, October 1921, page 1644.

The first named authors argue that the preparation of benzylidene-*dl*-piperitone is a convincing proof of the non-identity of piperitone with any of the menthenones hitherto described, whilst Simonsen shows that the Essential oil of *Andropogon iwarancusa* contains about 80% piperitone,

[1] This Journal, Vol. LV, 139, (1921).

and also produces evidence of its identity with $\triangle_1$-Menthenone-3.

The author during an investigation of the oxidation products of piperitone from the essential oil of *Eucalyptus dives* by means of potassium permanganate succeeded in isolating and identifying the following acids, viz:—

α-hydroxy-α-methyl-$\acute{\alpha}$-isopropyl adipic acid. Melting point 143·5° C.

α-isopropyl-γ-acetyl-butyric acid. Boiling point 175–177° C. at 12 mm.

α-isopropyl glutaric acid. Melting point 94–95° C.

This result is in entire agreement with Messrs. Schimmel & Co's work on $\triangle_1$-Menthenone-3 isolated from Japanese Peppermint Oil.[1]

In this connection, Simonsen[2] considers that the oxime of M.Pt. 110–111° C. prepared by Messrs. Read and Smith had probably not been entirely freed from the more fusible isomeride, and considers its correct melting point to be 117–118° C. This worker also gives the melting point of the α-semicarbazone as 225–227° C. This statement induced the writer to review his note book dealing with the initial work on lævorotatory piperitone from the oil of *E. dives* carried out between May and July 1919, and therein the melting point of the oxime is given as 117–118°, and the α-semicarbazone as 225–226° C., thus confirming the results of Simonsen. The piperitone used had $[\alpha]_{D\ 20°C.}$ – 54°C. The author had also been successful in preparing the three semicarbazones, viz:—

dl-α-semicarbazone M.Pt.	225–226° C.
dl-β-semicarbazone	175–176° C.
racemic ditto	188–189° C.

also in agreement with Simonsen's results.

[1] Semi-Annual Report, October 1910, pages 97–105.

[2] J.C.S., October 1921, page 1644.

Experimental.

It was found that oxidation with both alkaline and neutral potassium permanganate resulted in the production of the same acids, but in varying proportions, except that diosphenol was obtained only by oxidation with the neutral salt. On this account, the products of oxidation with neutral potassium permanganate only will be described.

In Part I Communication (Vol. LV, (1921), p. 139), about 7 grams of diosphenol were obtained by steam distillation from the liquors resulting from the oxidation of 104 ccs. piperitone. After concentration of the liquid, and acidifying with dilute sulphuric acid, it was subjected to a vigorous current of steam to remove the volatile acids, and allowed to cool. It was then repeatedly extracted with ether, when upon removal of the solvent, a viscous yellow oil was obtained. It was allowed to stand for ten days when it became turbid, this phenomenon being assisted by cooling in an ice bath. Subsequently on addition of excess of ether, a white crystalline solid separated, which was removed by filtration, and carefully washed with ether until free from oil. On drying on a porous plate and recrystallising from water, about 8 grams of crystalline acid were obtained, which melted at 143·5° C. Titration with deci-normal alkali solution showed it to be dibasic, and on heating above its melting point it readily split off water forming a lactonic acid.

0·1622 gram on combustion gave 0·3260 gram CO_2, and 0·1234 gram water.

	Found.	Calculated for $C_{10}H_{18}O_5$
Carbon	54·82%	55·04%
Hydrogen	8·45	8·25

Its formula, therefore, being $C_{10}H_{18}O_5$, it is no doubt identical with α-hydroxy-α-methyl-$\acute{\alpha}$-isopropyl adipic acid

described by Messrs. Schimmel & Co. in Semi-Annual Report of October 1910, page 102.

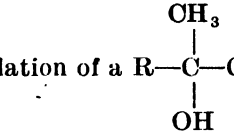
The filtrate from this acid, after removal of ether, was found to be a viscous deep yellow coloured oil, amounting to about 65 grams. On distillation it boiled at 175 – 177° C. at 12 mm., and had a refractive index at 22·5° C. of 1·4521. Titration with deci-normal alkali solution showed it to be monobasic. It readily reacted with semicarbazide hydrochloride solution forming a crystalline semicarbazone of melting point 158° C.

This derivative on combustion gave the following results, viz:—

0·1160 gram gave 0·2224 gram CO_2, and 0·0897 gram water.

	Found.	Calculated for $C_{10}H_{19}N_3O_3$
Carbon	52·28%	52·36%
Hydrogen	8·59	8·35

This acid appears, therefore, to be identical with α-isopropyl-γ-acetyl butyric acid. Its formula being $C_9H_{16}O_3$

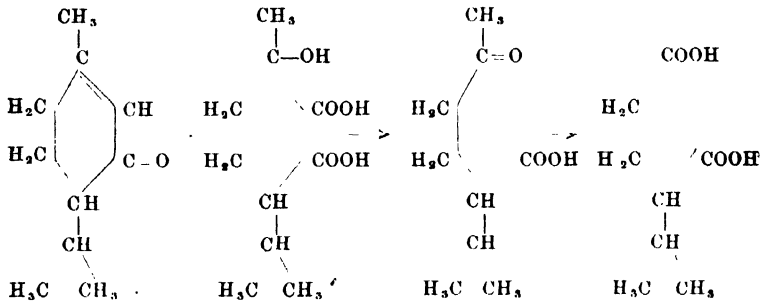
resulting from the oxidation of a  group

into R.CO.CH_3 group was confirmed by treating the acid with alkaline bromine liquor for one day at 0° C., when the methyl group was split off as bromoform. After removal of this latter body, and acidifying with sulphurous and sulphuric acids, an acid was obtained, which on recrystallisation from hydrochloric acid melted at 94 — 95° C. Titration showed it to be dibasic, and its identity with α-isopropyl-glutaric acid was confirmed by the preparation of the anhydride melting at 53 – 54° C. This acid was also present in the liquid acids produced by the oxidation of piperitone by means of alkaline potassium permanganate solution.

On combustion the following results were obtained, viz: 0·1270 gram gave 0·2580 gram CO_2, and 0·0932 gram water.

	Found.	Calculated for $C_8H_{14}O_4$
Carbon	55·24%	55·17%
Hydrogen	8·15	8·04

The generic relation between piperitone and the acids described is shown graphically, as follows, viz:—



Piperitone. | α-hydroxy-α-methyl-δ-isopropyl adipic acid. | α-isopropyl-γ-acetyl-butyric acid. | α-isopropyl-glutaric acid.

Piperitonehydroxylamino oxime.—Most of the published methods for the preparation of this substance require heating of the solutions, but the best method, in the author's opinion, particularly if using the highly active ketone, is the procedure usually adopted for the preparation of carvoxime, viz:—

Five grams of ketone in 25 ccs. alcohol and 5 grams hydroxylamine hydrochloride in 5 ccs. water, when cold, are mixed with a solution of 5 grams caustic potash in 5 ccs. water, also cold, and allowed to stand overnight. Within a few hours the whole solidifies to a solid mass. On washing with water, and recrystallising from alcohol and acetic ether a quantitative yield is obtained.

THE INCIDENCE OF ANTHRAX IN STOCK IN AUSTRALIA.

By MAX HENRY, D.S.O., M.R.C.V.S., B.V.Sc.

[*Read before the Royal Society of N.S. Wales, June 7, 1922.*]

AN enquiry was instituted some short while ago on the above question in connection with information sought on the infectivity as regards Anthrax of Australian Wool and the results appeared so striking that it was thought advisable to amplify the enquiry and to publish the results. The matter is of importance, not only to give the stockowner an accurate idea of the danger of Anthrax, but to place the position of New South Wales in its true light before those interested in other countries. There is at present a very considerable agitation, and one more than justified by the present state of affairs, in manufacturing countries owing to the danger to which operatives in the wool and leather industries are exposed through the handling of Anthrax infected material.

The degree of danger to which operatives are subject varies very greatly with the country of origin of the wool or other material. The actual state of affairs in this regard has been well demonstrated by the "Report of the British Departmental Inquiry, appointed to inquire as to precautions for preventing danger of infection from Anthrax in the manipulation of wool, goat hair and camel hair 1918."

A series of cases of Anthrax (See Vol. II, p. 18 of above report) occurring amongst workers in the wollen industries of Great Britain between the years 1899 and 1917 showed the following results, the infective material being the only material with which the patient was dealing:—

East India Wool	92	East India Goat Hair	4
Persian Wool	62	Alpaca	3
Turkey Mohair	27	Cowhair	2
Russian Camel Hair	10	Russian Goat Hair	1
Van Mohair	8	Australian & N.Z. Wool	4
Cape Mohair	5	Home Wool	2

Excellent as these figures are from the point of view of this country, they become still more significant if the quantity of wool imported into England from Australia and New Zealand be compared with that from, say, Persia.

In 1913 the two figures were, 446,259,861 lbs. and 1,864,720 lbs. respectively.

Of the samples recorded in the same report as having been examined for Anthrax in 1916-17, the following were found infected:—

East Indian Wool	29	Alpaca	4
Persian Wool	21	Grey Cowhair	1
East Indian Goat Hair	16	Scoured Oporto Wool	1
Egyptian Wool	4		

Between 1908 – 17, 33·3% of samples of East Indian goat hair examined bacteriologically were found infected with Anthrax.

Of sixty-four cases of Anthrax occurring at Mazamet in France, where an enormous industry in the removal of wool from sheep skins is carried on, 35 were traced to S. American, 22 to Spanish, 9 to North African, 4 to Hungarian, 3 to Cape, 1 to French, and 1 to Australian.

It may be mentioned here that Dr. J. B. Cleland of the Board of Health, investigated 29 fatal cases of Anthrax in human beings occurring in New South Wales. Between 1894 and 1904, 17 occurred amongst men associated with live stock, but with two exceptions these were men dealing with the animals or the carcases. No case was recorded of people working amongst wool being infected.

There is thus very sufficient evidence that Australian wool is remarkably free from Anthrax, and it is of importance to know to what extent such freedom is associated with freedom from the disease in stock, or is due to the discrimination in the marketing of wool from infected and possibly infected animals. To the uninitiated, a perusal of the daily press of this State during the last few years, would have conveyed the opinion that Anthrax was a serious and prevalent plague of live stock in New South Wales and that such an impression has been produced is not to be doubted. This attitude towards Anthrax is largely the result of the experience of past times, and in order to show the change that has been brought about, it is desirable to consider the history of the disease in this country.

The first outbreak recorded appears to have occurred at Leppington near Liverpool, N.S.W., according to W. M. Hamlet. (Intercolonial Medical Congress 1889).

In 1851 a commission of enquiry was appointed in New South Wales, John Stewart being the veterinarian of the Commission, and it was found that the disease existed on the Sydney side of the Blue Mountains.

By 1859 it appeared to have been introduced to the Lachlan, Castlereagh, and Liverpool Plains Districts, and according to the Report of the Anthrax Board 1889, in 1866 it had been recorded on the Darling Downs in Queensland, and by 1876-7 on the Western District of Victoria.

Gordon writing in 1868 to Mitchell stated that some ten or fifteen years since the disease was almost ruinous in the districts immediately south of the Liverpool Plains and in the Orange and Wellington Districts (N.S.W.), and further "we find it to have existed in a very virulent form in the country lying between the Razorback and Bargo in County Camden, N.S.W."

In 1876 A. Park, M.R.C.V.S., a veterinarian practising at Warrnambool reported sheep dying of blood poisoning in an epizootic form, and G. Mitchell, M.R.C.V.S., declared in the same year that the disease was Anthrax, a diagnosis with which Park concurred. Graham Mitchell carried on a fierce controversy with the officials in Victoria over the question, and published the correspondence ensuing therefrom in 1877 under the title of "Cumberland Disease," so called new disease. Hamlet records that in 1883 Anthony Willows, M.R.C.V.S., reported on the prevalence of Anthrax on the Lachlan, and advocated vaccination. In 1885 Edward Stanley, F.R.C.V.S., again recommended vaccination when reporting on the disease at Narrandera, and in 1888 Pasteurs representatives gave the demonstration in Anthrax Vaccination at Junee, whence arose the work of A. A. Devlin followed by J. Gunn and later McGarvie Smith.

The earlier records of the disease in the State are of course very incomplete, but odd notes are available from the reports of the Chief Inspectors of Stock from 1869 onwards. In that year the disease was reported in twelve out of thirty-four districts in what are termed the coast, upland and intermediate portion of the colony. In 1870 Bathurst, Dubbo, Canonba, and Tamworth reported Anthrax in cattle and a few districts in sheep, and in 1871 the north western districts reported the disease in sheep, and Dubbo, Forbes, Narrabri, Canonba, and Tamworth in cattle. From that time on to 1879 the disease appears to have been very little in evidence and in that year it was reported to a slight degree in cattle in five districts and not at all in sheep.

Nothing of importance is noted with regard to Anthrax until 1885, when it was referred to in the following terms:

"This scourge which is known in the Australian colonies as Cumberland Disease, has I regret to say, been prevalent during

the past year in several parts of the colony; and an outbreak which was attributable by the owners to poisonous plants, was investigated and reported on by the Government veterinarian."

In 1886 the disease was very disastrous in some districts, the sheep dying by thousands. For the next few years the reports are serious, then in 1892 the disease is reported as being less virulent, and this continues until 1894, when it is stated that "there have been no serious outbreaks during the past year."

During this period the highest number of cattle reported officially as dying from Anthrax was 1,780 in 1887, and 1,216 in 1888, but these figures are not reliable. They are, however, a comparative guide.

In 1894 the disease showed a tendency to spread, or else was more fully reported owing to the benefits to be obtained from vaccination. From that date on to 1900 the reports are very unenlightening, each one stating that Anthrax is apparently on the increase (no details given) yet in the report for 1900 it is stated no outbreaks of the disease in sheep occurred, but that 525 head of cattle died from it. Either the reports for the previous years are worth nothing, which is most probable, or there was a very sudden decline. There is then a marked silence regarding Anthrax—it was evidently fairly quiescent. In 1908 it was reported that in the previous year eight outbreaks occurred, whilst from 1909 on the officially recorded figures are:—

Year.	Outbreaks.	Year.	Outbreaks.
1909	3	1916	5
1910	5	1917	2
1911	4	1918	6
1912	4	1919	4
1913	10	1920	8
1914	8	1921	13
1915	8		

Vaccination.

The evidence of the steady decrease of Anthrax of late years shown by the official records of outbreaks is further borne out by a consideration of the numbers of stock vaccinated. The figures especially in the earlier years are probably not complete, but they furnish a reliable comparative guide.

Stock Vaccinated against Anthrax in New South Wales.
(Official Records.)

Year.	Horses.	Cattle.	Sheep.
1891	...	...	193,098
1892	...	...	98,261
1893	...	...	70,029
1894	...	...	119,380
1895	...	...	616,406
1896	...	...	346,689
1897	...	283	651,056
1898	...	329	643,354
1899	16	7,547	1,227,378
1900	...	2,618	1,063,191
1901	...	5,331	1,492,195
1902	...	11,395	1,519,069
1903	...	12,431	1,129,671
1904	...	12,601	1,611,546
1905	...	9,030	1,289,027
1906	No Record.		
1907			
1908			
1909			
1910	...	5,557	574,405
1911	...	2,062	359,598
1912	...	579	325,194
1913	67	300	192,081
1914	...	1,237	339,641
1915	...	750	82,626
1916	...	691	301,061
1917	...	571	149,603
1918	...	1,414	421,088
1919	25	1,916	179,042
1920	39	794	99,073

These figures indicate quite plainly that the stockowner has recognised the lessening risk of Anthrax.

Seasonal Incidence.

It is not infrequently asserted that wet periods are favourable to the occurrence of Anthrax, and dry periods unfavourable, and Norris giving evidence before the Departmental Committee, asserted that "in Australia the evidence of Anthrax is greatest in the late spring and early summer which would be relatively wet seasons."

In other countries, notably England, this is not held to be the case; Stockman holding the view that there is no seasonal difference. Stockman is however, dealing in England with a totally different set of conditions, to those holding sway in Australia. However, he asserts that French and South African statistics bear out his view, but he admits that in Russia cases rise enormously in the summer.

Stockman's assertion *re* Anthrax in South Africa is evidently not concurred in by Kehoe (Anthrax in South Africa 5th and 6th Reports of the Director of Veterinary Research) who regards the disease as more prevalent from December to April than at other seasons, thus bringing the seasonal incidence in South Africa in a line with the period of the maximum of occurrence here as will be noted later.

A review of our records in New South Wales supports the view that the seasonal incidence is marked, but does not fully bear out Norris' dictum that most cases occur in spring and early Summer.

During the period 1909–1921, out of 80 outbreaks which are regarded as being without doubt Anthrax, and of which actual dates are known, the numbers occurring in each month of the year were as follows:—

January	19	July	0
February	12	August	1
March	8	September	0
April	6	October	8
May	1	November	11
June	2	December	12

In Victoria, during the years 1909 to 1921, out of 40 outbreaks regarded as undoubtedly Anthrax, the distribution was as follows:—

January	3	July	4
February	7	August	3
March	5	September	2
April	6	October	1
May	1	November	2
June	4	December	2

From this it will be seen that the Victorian figures rather support Stockman and completely negative Norris' evidence. The difference in the two States might be thought to be due to the degree of settlement which had taken place with its consequent change in the methods of animal husbandry, and this may be the explanation. Briefly the maximum period of danger from Anthrax in Australia is the summer and early autumn. This fact will receive support if some of the figures dealing with vaccination as a preventive are noted. In 1917 vaccination is recorded as having been carried out on 260 holdings, and the vaccination was distributed throughout the year as follows:—

January	44	August	2
February	46	September	1
March	22	October	10
April	5	November	51
May	2	December	46
June	1		
July	0	Total	260

In 1914 33 holdings were quarantined on account of preventive inoculation; of these 20 were quarantined in January, 2 in February, 1 in March, 1 in October, 4 in November, 5 in December. The 1912 figures read: January 25, February 1, March 1, September 4, October 25, November 23, December 23. Other years' records bear out these figures. Now if, as Norris held, spring and early summer

were the seasons of greatest prevalence, the bulk of the vaccination would not be carried out from October to February, but from July to October.

Norris appears to have based his dictum on the alleged fact that spring and early summer is a wet period of the year, but this is not borne out by the Statistical Register for New South Wales, and it was obvious that such a statement could not possibly be made for the whole of the continent. From the Statistical Register for 1918-19 the following figures are taken representing the average rainfall in each month for the years 1907 – 1918 for six typical localities within the Anthrax belt.

Average Monthly Rainfall 1907 – 1918.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Dubbo ...	293	198	213	114	134	252	190	175	123	113	197	197
Forbes ...	216	142	138	101	101	219	180	187	135	136	157	173
Albury ...	156	150	177	114	277	354	316	271	240	233	202	184
Wagga ...	149	144	143	73	159	270	193	206	195	180	153	147
Condobolin	224	133	130	70	94	183	142	165	115	103	140	174
Nyngan ...	223	106	88	90	95	161	98	112	67	97	130	226
Bourke ..	123	109	62	55	84	132	103	77	38	81	113	143

If this table be compared with the monthly record of outbreaks on page 50 it will be seen that there is not any very marked connection between outbreaks and rainfall, April the driest month of all having as many outbreaks as November, while June, July and August, months of comparatively heavy rainfall are very free from Anthrax. September and October, the two typical spring months are not markedly wet.

Localisation of Anthrax.

In spite of the fact that Anthrax has existed for so many years in Australia, it has remained curiously localised. At the present moment New South Wales is unquestionably the State which suffers most severely from Anthrax, but

even in this State the area in which infection from Anthrax may be expected or feared is limited. Taking the State in divisions according to its well known geographical features, it may be said that the whole coastal area, except for one spot a few miles south of Sydney, (close to the locality of the first recorded outbreak) is free. When it is remembered that the disease obtained the name of Cumberland Disease from its prevalence in the central coastal area, this is of interest. (It is true that in 1912 mortality ascribed to Anthrax occurred at one spot on the far North East Coast, but some doubt exists in this instance).

The tableland areas are and always appear to have remained free from the disease. This area includes the country as far west as Mudgee, Molong, Young and Holbrook. North of a line joining Tamworth, and Coonamble, the clean country stretches right across the north-west plains until the Bogan River is reached, and south of this line is a large area in which Anthrax is all but unknown. It has already been noted that in 1871 it was reported in the New South Wales districts such as Narrabri, but this evidence cannot be fully accepted as will be seen from remarks *re* possible source of confusion.

The Hunter Valley presents two known Anthrax spots involving small groups of farms, but is otherwise free.

The real Anthrax country occurs in a belt between the tablelands and the western plains, and its extent may be gauged from the fact that west of a line drawn from Bourke through Narrandera, Jerilderie and Deniliquin to Echuca, the disease appears to be unknown, with the exception of two possible spots a little west of Bourke and one near Wilcannia, all on the river bank. Not that it is to be assumed that this belt is all Anthrax infested. That is far from the case. For instance, within it is the whole of the Pastures Protection District of Molong, 80×60 miles, in

which no case of the disease is recorded since 1915, four-fifths of the P.P. District of Urana in which Anthrax is unknown, and many similar areas. However, there do exist in this belt somewhat well defined areas in which Anthrax has occurred severely in the past and where it occasionally recurs.

Judging by past records these areas are steadily and continuously decreasing in number and extent. The position in Victoria is one of equally remarkable interest. If the outbreaks officially recorded are taken from 1909 to 1921, it will be seen that with one possible exception they are all included in an area between two lines, one drawn from Casterton to Echuca, the other from Albury to the northern shore of Western Port. Within this area the outbreaks are again grouped in certain well defined localities. As will be noted, this area is practically an extension to the south and west of the New South Wales Belt.

Again we have to note a steady decrease in the number of outbreaks. For the last few years they have been as follows:—

1909	...	9	1915	...	2
1910	...	5	1916	...	2
1911	...	7	1917	...	1
1912	...	3	1918	...	0
1913	...	2	1919	...	3
1914	...	1	1920	...	1

What gives peculiar interest to the recent distribution of Anthrax in Victoria, is the fact that in 1877 Graham Mitchell published a map showing the area of country which Park and himself declared to be infested with Anthrax. Their statement met with strenuous opposition, particularly from the State Officials, but it is evident that they were very close to the truth for the area they declared infected, except for a small extension to the north, agrees

exactly with the area in which Anthrax occurred during the years 1909 to 1921.

In Queensland the disease is officially declared to be non-existent, and all the evidence available goes to support this view. Moreover, it has already been shown that the continuous belt running through Victoria and New South Wales completely disappears some distance before the Queensland Border is reached, and Norris giving evidence before the British Departmental Committee on Anthrax in 1918, reported that it had never occurred in Queensland. Against this, however, Mitchell in his book quotes P. R. Gordon, late Chief Inspector of Stock, Queensland, as reporting Anthrax on the Darling Downs in 1868, particularly on Dunmore and Cecil Plains, and also on the New South Wales Border and in Maranda.

In 1877, however, Gordon writing to Mitchell said, "at the time of my first report, the disease was very rife in this colony. . . . we hear little of it now except occasionally odd instances and these confined to . . . rich soils in spots on Darling Downs and Maranda districts." Such a history if taken on its face value is almost unbelievable. There is not on record, so far as can be found, any instance of a district or country in which ten years after Anthrax is reported to be very rife it has practically disappeared and is not again recorded, although forty years have passed since the last record. Certainly Anthrax has, if the reports can be trusted, disappeared in an equally complete fashion from many districts in New South Wales, but nowhere with such rapidity, and naturally an impression of doubt is left as to whether Anthrax ever existed in Queensland. In South Australia the disease is practically unknown, and Western Australia is declared at the present time to be free, and certainly if Anthrax exists there at all it must be very localised and of little importance. According to the Pro-

ducers' Gazette and Settlers' Record of W.A., Vol. v, 1898, a veterinarian attached to the Stock Department, reported it as occurring at Koogan on the Midland Railway in that year, and it is said to have occurred in one or two other places during the nineties. Here again we are left in considerable doubt as to the true state of affairs.

In Tasmania it appears to have been reported definitely from only three centres, and is evidently negligible. In a private communication the Government Veterinary Surgeon Mr. T. Philp, B.V.Sc., states that some cases are attributed to the use of bone dust, a source of infection which must be very unusual in this country.

Mortality.

It is not sufficient to show that outbreaks of Anthrax are not numerous, in order to establish the comparative freedom of Australia from the disease, unless at the same time it is possible to demonstrate that the mortality involved by such outbreaks is also light. In past years the estimates of loss were very high, but for reasons which will be mentioned later, it is not considered that such estimates are reliable. It is not intended of course to convey the impression that Anthrax was not at one time in certain districts a veritable scourge. In 1891 Loir, before the Royal Society of New South Wales declared that the figures generally accepted as the loss in sheep from Anthrax in New South Wales were 200,000; whilst Hutyra and Marek (Special Pathology and Therapeutics of the diseases of Domestic Animals 1912) say, "In Australia it was not supposed to have been introduced until the year 1847, but at present it causes an annual loss of 300,000 sheep." Now if the official figures are considered, it will be found that in those outbreaks occurring in New South Wales and Victoria from the period 1/1/12 to 31/12/21, that is ten years, actual mortality figures are available in 32

outbreaks in New South Wales and 25 outbreaks in Victoria, that is to say in about half the total number of outbreaks recorded. In the 32 outbreaks in New South Wales, 469 animals died, an average of 14·65 per outbreak, the maximum number being 100, and the minimum 1. In the 25 outbreaks in Victoria 88 animals died, an average of 3·52 per outbreak, the maximum number being 14 and the minimum 1. These outbreaks are in no way selected ones, but quite typical of the whole number. During the same period the mortality for the rest of Australia was quite negligible. It is evident that the mortality has been much exaggerated.

Possible sources of confusion as to the extent of Mortality.

It may well be asked whether there is any justification for the somewhat suspicious attitude adopted regarding the reliability of records of mortality due to Anthrax. Loir in 1891 pointed out that mortality caused by Anthrax was imputed to poisonous plants; no doubt that was correct, but on the other hand the converse was equally correct, and a careful study of the reports and records will make it plain that mortality which is now known not to be due to Anthrax, and which is due to the toxic effects of plants, was up to quite recently (*i.e.*, ten years ago) regarded as unquestionably due to Anthrax, The fact of cyanogenesis in plants was not then understood, and as prussic acid poisoning is responsible for very heavy mortality on certain areas and at certain seasons, these deaths were invariably attributed to Anthrax. On the banks of the Macquarie, Namoi, and other rivers in what was then held to be Anthrax infected country, there were, and have been for many years, small areas of country over which stock can only be travelled with much risk in certain seasons. There have been within the last few years instances of several hundred animals dying in a single night. Analysis of the blue couch, (*Cynodon incompletus*) which is particularly to be found in

these areas, has shown the presence of hydrocyanic acid. The records make it very clear that in the past such mortalities were ascribed to Anthrax. In other instances tympanites amongst hungry travelling stock was also described as Anthrax.

On the other hand some at least of the mortality ascribed to feeding on *Euphorbia Drummondii* probably was really Anthrax.

Source of infection of Anthrax in Australia.

It has been widely held that the source of infection in Anthrax was the soil contaminated by the blood of a previous case, but as regards the disease in England, Stockman has put forward reasonable evidence to show that infected food material introduced from abroad, was responsible for the majority of outbreaks, whilst elsewhere infected bone dust was looked upon as a serious factor. The conditions under which stock are kept in most of the Anthrax infected areas in Australia enable it to be laid down with certainty that soil infection is responsible for the continuance of the disease in this country. The stock in the areas referred to are all grazed, only in times of severe drought is any food, other than what they pick up, supplied to them, and such drought periods are not in any way associated with Anthrax, moreover the constant localisation of the disease would be impossible if infection were carried by the food. The use of artificial manures such as bonedust was unknown in the Anthrax belt when the disease was at its height, and though possibly they may be utilised to some slight extent now, that increase in use would be coincident with the decrease in Anthrax. As noted, it was held with regard to one case in Tasmania, that bonedust was the infecting agent, but such a cause must be altogether exceptional. Again, the localisation of the disease would negative such a theory. This explains the reason why the veterinary authorities

are so insistent on obtaining the destruction by fire of carcases dead of Anthrax.

Reason for the Decline of Anthrax.

Looking at the past and present distribution of Anthrax in Australia it must be evident that certain naturally occurring inhibitive factors have been obviously active. The disease was first reported near Sydney, and this fact was confirmed by the Commission of 1851. Then it appeared far inland on the Lachlan and Castlereagh. If it ever infected the intervening country it can only have been for a comparatively short period. Over the roads from Sydney to Bathurst and Sydney to Goulburn must have travelled hundreds of thousands of head of stock, horses, cattle and sheep, from the Anthrax infected area of the County of Cumberland, but Anthrax is unheard of to-day along those roads, and in the country through which they pass. During periods of drought sheep from what were and are Anthrax infected districts are removed for agistment to other areas, as for instance the snow lease country of Kosciusko and the Monaro, in enormous numbers, while cattle from the west and north-west, some at least of which must come from Anthrax areas, pour down into the coast, and yet this relief country remains and always has remained free from Anthrax. It is evident that moisture alone is not the deciding factor, since the coastal country, especially in the north, has a much heavier rainfall than the country in which Anthrax is most prevalent. Nor is heat alone the controlling factor, since the north-west plains, and the country north of the Darling River are quite as hot and no drier than the country to the south which is infected. Over the western part of the State, the low rainfall and dry heat may sufficiently explain the fact that Anthrax is non-existent, but what the factor may be which has led to the prevalence of Anthrax in the first place and its subse-

quent maintenance in the affected areas, it is impossible to say.

The decrease in the prevalence of the disease is due partly to natural causes, and partly to human action. The disappearance of Anthrax in many districts was not due to action on the part of man, and no explanation can be offered as to why it ceased to exist and yet persisted elsewhere, save that natural conditions were unsuited to it, but its control elsewhere, the prevention of its spread and the gradual diminution of the affected area must, to a large extent, be ascribed to definite action taken against it. These measures were, vaccination, the destruction of carcases by burning, and quarantine of affected flocks and holdings. There is, as a rule, a tendency to overrate the comparative value of vaccination as opposed to the other measures adopted, and to leave entirely out of account those natural but unknown factors which have unquestionably greatly influenced the incidence of Anthrax in Australia. For it has to be noted that these factors were evidently in existence, not only in New South Wales but in Victoria, and, if the evidence of Gordon is to be accepted, to a still greater extent in Queensland. Other factors which have influenced the incidence of Anthrax have been (1) the substitution of farming for grazing in many of the worst Anthrax localities, (2) the subdivision of farms and stations so that less country became contaminated.

That this is so is plainly obvious from the history of the disease, in spite of Norris' statement before the Departmental Committee that ploughing operations would tend to increase the incidence of Anthrax. Whether the evidence in support of such opinion is of value or no, or whether it is true, it is quite evident that other factors involved in the change from grazing to farming more than counterbalance whatever tendency in that direction may exist.

Viewing the question as a whole, it would appear that the future may be looked forward to with confidence. The further subdivision of large estates in the Anthrax belt should lead to a corresponding reduction in mortality, because owing to the restrictions on the movement of stock, smaller areas will be recontaminated at each outbreak, and gradually it may be anticipated that the disease will die out. With more efficient methods of control and the more accurate means of diagnosis available, it is to be expected that outbreaks will be dealt with more promptly, and the number of cases reduced. On the part of the farmer and stockowner, action is only required on two matters to bring about the desired result, prompt notification of mortality which might be due to Anthrax, and destruction by fire of all carcases of animals dead of Anthrax.

NOTES ON THE GENERA *DARWINIA HOMORANTHUS* AND *RYLSTONEA* IN N. S. WALES, QUEENSLAND, AND SOUTH AUSTRALIA.

By EDWIN CHEEL.

[*Read before the Royal Society of N. S. Wales, June 7, 1922.*]

DARWINIA.

THE genus *Darwinia* was founded by Rudge (Trans. Linn. Soc. XI, 299, (t. 22), 1815) the species *fascicularis* being the type of the genus. Schauer (Myrt. Xeroc., 1840) in his monograph of the tribe Chamælaucieæ of Myrtaceæ maintained two genera, enumerating all the western species under *Genetyllis* and the two eastern ones under *Darwinia*. He further states,

"That in *Genetyllis* the staminodia are equally distant from the sepaline and from the petaline stamens (those opposite the sepals and petals respectively) whilst in *Darwinia* they are nearer to the petaline ones, thus showing they belong to a different series from those of *Genetyllis*."

Bentham (B. Fl. iii, 6, 1866) set up two sections in the genus *Darwinia*, namely, *Genetyllis* with 18 species and *Schauermannia* with 7 species making a total of 25 species. In his key to the species, Bentham subdivided his section *Genetyllis* into three subsections, placing *D. fascicularis* and *D. taxifolia*, the two species with which we are chiefly concerned in this paper under subsection C, with the following definition of characters:—"Flowers in terminal heads or in the upper axils, the floral leaves or bracts not very different from the stem leaves."

The chief characters of the two species referred to above under this subsection are as follows:—

"Leaves mostly opposite, triquetrous or laterally flattened. Flowers 2 to 4 in the head. Petals ovate. Staminodia small and subulate."—*D. taxifolia.*

"Leaves semiterete. Flowers sessile or nearly so. Calyx 5-ribbed, smooth."—*D. fascicularis.*

HOMORANTHUS.

The genus *Homoranthus* was established by A. Cunningham (in Schau. Myrt. Xeroc. 191, t. 3, 1840), on specimens collected on Islands of Moreton Bay, Queensland. In addition to *H. virgatus*, which is the type of the genus, Cunningham described another species under the name *flavescens*, from specimens collected in forest lands skirting Liverpool Plains and Molle's Rivulet below Wellington Valley. Bentham *l.c.*, united it with *H. virgatus*, saying that he could not discover any difference whatever between the two species.

VERTICORDIA.

This genus was established by A. P. DeCandolle, who took up the species published under the name *Chamælaucium plumosa* by Desfontanes in Mem. Mus. Par. v, 42, t. 4, 1819. The specific name *plumosa*, should therefore, be the type of the genus, and not *V. Fontanesii* of DeCandolle, which was not published until 1828, vide DC., Prod. iii, 209, 1828.

Bentham established two sections for the species of this genus, namely, Sect. I. *Euverticordia* with the following characters:—

"Anthers nearly globular, opening in two almost dorsal pores; connective either small and inconspicuous or more or less thickened, or produced into a concave or hooded appendage concealing the pores. Ovules 2 or rarely 4 or 1, on a small or stalk-like placenta."

He also remarked "this section, with the anthers and ovary of *Darwinia* and *Homoranthus*, is only distinguished from them by the calyx." The section was divided into two subsections, namely, Subsection A.—"Calyx-tube narrow, 5-ribbed, glabrous; primary lobes 5, erect, each divided into 3 to 5 long, simple hair-like lobes."

Only one species was placed under this subsection by him namely, *Verticordia Wilhelmii* F.v.M., (Trans. Vict. Inst. p. 122, 1855), and he remarks that—

"This single species differs from all others of the genus in inflorescence and the shape of the calyx; and in its lobes forms an approach to those of *Homoranthus*"

In 1898, Maiden and Betche, (Proc. Linn. Soc. N.S.W., XXIII, 17) described a species from specimens collected at Dubbo, N.S.W., under the name of *Verticordia darwinioides*, drawing attention to the close affinity of their new species with *V. Wilhelmii* F.v.M., a Port Lincoln, South Australian species, with which it has the narrow calyx-tube in common, but stating that it forms a still closer connecting link between *Darwinia* and *Verticordia* than *V. Wilhelmii* does. They further state that "The general appearance of the plant is quite that of a *Darwinia*, an effect chiefly produced by the large persistent bracteoles, so uncommon in *Verticordia*, and by the comparatively inconspicuous fringes of the calyx-lobes, generally so very conspicuous in *Verticordia*. Although the paper containing the description of this new *Verticordia* was read in March 1898, Mr. R. T. Baker in November of the same year, submitted for publication in the same Journal a description of the same species as a proposed new genus.

RYLSTONEA.

R. T. Baker (Proc. Linn. Soc. N.S.W., XXIII, 768, 1898). Comparisons with cognate genera were given as follows:—

"Calyx cylindrical, lobes broad, entire or shortly ciliate, flowers in heads."—*Darwinia.*

"Calyx cylindrical, lobes 5, subulate, entire, flowers in heads." —*Homoranthus.*

"Calyx cylindrical, lobes 5 to 10 digitately divided, flowers nodding, not in heads."—*Rylstonea.*

"Calyx hemispherical, lobes 5 or 10 deeply divided into subulate plumose or hair-like processes, flowers in corymbose heads." —*Verticordia.*

Now if we carefully analyse the characters as given above, we must arrive at the conclusion that the plants placed in the genus *Rylstonea* are as already suggested by Maiden and Betche (*op. cit.*, XXIV, 645, 1899) "decidedly a connecting link between *Verticordia* and *Darwinia* (including *Homoranthus*)." It remains to be seen, however, if the "shape of the calyx and the calyx-lobes," characters upon which both Cunningham and Baker have founded the respective genera *Homoranthus* and *Rylstonea* are sufficiently strong to maintain them when carefully studied with the abundant material that has since been brought to light. Even Bentham[1] who had less material to work upon, doubted if *Homoranthus* of Cunningham could be maintained as a good genus, for we find he says :—

"*Homoranthus* A. Cunn , is a single species which has scarcely even the claims of *Actinodium* to be excluded from *Darwinia*, differing from the latter genus only in the subulate calyx-lobes. Its retention may, however, be justified as facilitating the distinction between *Darwinia* and *Verticordia*."

Then we have some remarks by Baillon ("Natural History of Plants," VI, 323, 1880), as follows:—

"Some species of *Darwinia* differ from *Chamælaucium* only in the form of their anthers, the latter being nearly globular and opening near their organic summit, that is above and without, by

[1] Jour. Linn. Soc. (Bot.) Vol. x, p. 129, (1869).

two pores more or less confluent within. The flowers are in terminal capitules and situated in the axil of narrow or often wide and coloured bracts, forming a petaloid involucre. The sepals are mutichous, sometimes glandular at the summit. *Actinodium* is a *Darwinia* with tetramerous diplastemous flowers and stamens not accompanied by sterile tongues. *Homoranthus* on the other hand, has these tongues in the intervals of its ten fertile stamens, for its flower is pentamerous and in other respects it is quite that of a *Darwinia*, but the sepals are attenuated at the summit to a long subulate point, as we shall find those of *Calythrix* are; and this character, which otherwise would be of the smallest importance has been thought sufficient here to distinguish this quite artificial genus."

Having given a brief summary of the characters on which the above mentioned genera were founded, we will now bring under notice three other species which appear to me to have characters very similar to those mentioned above, namely, *Darwinia Schuermanni* Benth., *(Schuermannia homoranthoides* F.v.M.*)* from Boston Point, Port Lincoln, S.A., *D. Thomasii* Benth., a Queensland plant, and *D. verticordina* Benth. The calyx-lobes of the two latter are described as " very shortly and irregularly denticulate-ciliate" and "minutely denticulate." In *D. Schuermanni* (which by the way is to be found in the same locality as *D. Wilhelmii*), the flowers are solitary in the upper axils, of short branchlets, on very short pedicels. It will thus be seen that, in addition to *D. Wilhelmii*, there are two other species which occur, in South Australia and Queensland respectively, and if geographical distribution is to be taken into consideration, this fact should be as important as the point made by Mr. Baker, in connection with *D. Wilhelmii*, viz:—"so far from the home (Western Australia) of *Verticordia*." In establishing the genus *Rylstonea*, Mr. Baker states,[1]

[1] Proc. Linn. Soc. N.S.W., xxv, 664, (1900).

"It is on the shape of the calyx and the calyx-lobes that my genus is based,—characters upon which Cunningham founded the cognate genus of *Homoranthus*, and which determination was supported by Bentham and Hooker, in their 'Genera Plantarum,' and from these features alone I think I am justified just as much as Cunningham in establishing a new genus on my material."

Mr. Baker had apparently overlooked the statements of both Bentham-Hooker, and Baillon in connection with *Homoranthus*, which, as stated by them, was retained to facilitate the distinction between *Darwinia* and *Verticordia*. In *Verticordia* everything in the flower is equally that presented by *Darwinia*, but the sepals, usually 5 to 10 in number are cut up into rather long plumose or ciliate strips (except in *D. verticordina* and *V. Thomasii*), which as already explained, are very shortly and irregularly denticulate ciliate. The flowers are also accompanied with two lateral bracteoles which are comparatively wide, rounded concave and imbricate in such a manner as to form around the bud a complete accessory envelope; these are very caducous.

The anthers in both *Verticordia* and *Darwinia* are practically the same, being more or less globose opening in two almost dorsal pores in the former and in the latter terminal pores or short slits. The ovary and ovules appear to be very variable, as in general the ovary is 1-celled, in all the genera under consideration, but the ovules are said to be 2, 3, and 4 in *Darwinia*, 4 in *Homoranthus*, 2 or 4 on a central excentric placenta, or about 8 or 10 on a more or less peltate placenta in *Verticordia*. It is interesting to note that the ovary and ovules of *Rylstonea cernua* are practically the same as those of *Verticordia* as the following particulars will show, as given in Mr. Baker's description of *Rylstonea*, namely, "Ovary 1-celled, about 8 ovules on a peltate central placenta, with two processes at the

summit." Maiden and Betche in describing *Verticordia darwinioides* state that the ovary is 1-celled with 2 ovules. Then we have *Darwinia Thomasii* with 6 ovules. Thus it will be seen that the stamens and staminodia, together with the anthers and their cells and openings, as well as the calyx-tube and the lobes with their digitately-plumose, fringed, ciliate or denticulate margins, are extremely variable in the different genera, and as yet there appears to be no distinct line of cleavage in the number of ovules of the different genera as defined above. In view of this I propose to submit the following descriptive key, which embraces those species found in New South Wales, Queensland, Victoria, and South Australia, and which are best retained in two genera, namely *Darwinia* and *Homoranthus*.

* * * * *

Key to the species of *Darwinia* and *Homoranthus* in Queensland, New South Wales, Victoria and South Australia.

DARWINIA, Rudge.

(*Section Genetyllis* Benth.)

A—Calyx-tube narrow, ribbed, the calyx-lobes entire or very minutely ciliate or denticulate, not exceeding half the length of the petals and often very minute.

(a) Leaves semiterete, crowded. Flowers sessile or nearly so. *D. fascicularis.*

(b) Leaves triquetrous, or laterally flattened, mostly opposite and bifarius. Leaves 15—20 mm. long. Flowers sessile, about 8 mm. long, usually 4 together in terminal heads. Bracts broad, truncate. *D. grandiflora.*

Leaves 6—8 mm. long. Flowers sessile, about 5 mm. long. Bracts mucronate-acute, slightly longer than the flowers. *D. taxifolia.*

Flowers sessile, usually only 2 in the axils of the upper leaves, 7 mm. long. Bracts obtuse about as long as the flowers. *D. taxifolia* var. *biflora.*

(c) Leaves rather crowded, not bifarius but more or less triquetrous. Flowers 4—5 mm. long. Bracts two-thirds as long as the flowers.
D. taxifolia var. *intermedia.*

(*Section Schuermannia* F.v.M.)

B—Calyx-tube narrow ribbed, the calyx-lobes entire, as long as the petals or longer.

(a) Flowers few in the upper axils. Leaves linear-triquetrous. Flowers very shortly pedicellate.
D. Schuermanni.

Leaves obovate. Flowers on rather long pedicels.
D. Thomasii.

(b) Flowers several together, in small compound nearly globular heads. *D. micropetala.*

HOMORANTHUS A. Cunn.

(A)—Calyx-tube narrow, ribbed, the calyx-lobes attenuated at the summit to a solitary hair-like point.

Leaves semi-terete, greenish, not crowded. Flowers and bracts reddish. *H. virgata.*

Leaves more or less linear-triquetrous and falcate, crowded. Flowers and bracts yellow.
H. flavescens.

(B)—Calyx-tube narrow, ribbed, the calyx-lobes digitately divided into 3 to 5 or more hair-like divisions.

Flowers two together on a common peduncle.
H. darwinioides.

Flowers numerous, in umbel-like corymbs.
H. Wilhelmii.

Darwinia fascicularis Rudge in Trans. Linn. Soc., XI, 299, [t. 22](1815); Schauer. Myrt. Xeroc. I, 188; 2, D.(1840); Walp. Repert. ii, 153 (1843); Benth., Journ. Linn. Soc. (Bot.) IX, 176, (1865); B.Fl. iii, 13, (1866); Baker and Smith

this Journ., XXXIII, 163 (1899); *Cryptostemon ericæus* F.v.M., in Miq. Nederl. Kruidk. Archief. IV, 115 (1856); *Francisia* of Endl., which, according to Bentham, (Journ. Linn. Soc., (Bot.) X, 128 (1869) was founded on a drawing of Bauer's of the original *D. fascicularis*.

The original specimens on which the species *fascicularis* the type of the genus *Darwinia* was founded, were collected in the Port Jackson district. The description, together with the figure, enables one without any difficulty to identify the plant, which is fairly common in the sandstone country around the coast. The only locality given by Bentham *l.c.*, is Port Jackson, but, as shown by Messrs. Baker and Smith, *l.c.*, it has a much wider range. Haviland, (Journ. Linn. Soc. N.S,W., 2nd Series, i, 65 and 1050, 1886), has made reference to its flowering period, Dr. S. J. Johnston (*ib.* XXXV, 424, 1910) has referred to it as representing a Jordanian Geminate species. A. G. Hamilton and Miss Brewster, in the same journal XXXIX, 152, 1914 and XL, 753, 1915 respectively, have referred to the xerophitic and proterandrous characters. It has also been listed by Dr. J. M. Petrie (*ibid*, XXXVII, 226, 1912) with other plants as having no positive results when tested for hydrocyanic acid. In the National Herbarium, Sydney, specimens are represented from the following definite localities: Middle Harbour, J. H. Camfield; Kurnell, J. L. Boorman; Cronulla, A. A. Hamilton and E. Cheel; Loftus, J. H. Camfield; Asquith, Wahroonga, and Hornsby, W.F. Blakely; Woodford, A. A. Hamilton; and Wentworth Falls J. H. Maiden.

Darwinia taxifolia A. Cunn. in Fields' "Geographical Memoirs on New South Wales," 325 (1825); B. Fl., iii, 12, (1866) in part; A. G. Hamilton, Journ. Linn. Soc. N.S.W., XXIV, 358, and A. A. Hamilton, *ibid.*, XL, 398, 1915. The following is a copy of the original description:—"Foliis

linearibus falcatis mucronatis sparsis. Rocky declivities on the Blue Mountains." In Don's "Dichlamydeous Plants," ii, 812 (1832), it is again referred to and described as a decumbent shrub, leaves acinaciform, style shorter than the flower. Calyx white."

Then we have *D. laxiflora* J. S. Schauer, Myrt. Xeroc., 190 (1840). In the latter work it is described as follows:— "Foll. falcatis acinaciformib. laxe fasciculatis; style exserta parte flore breviore."[1] B. Fl., iii, 12 (1866) includes *D. laxiflora* Schau. as a synonym, and states that Schauer was mistaken in supposing that A. Cunningham's specific name of *taxifolia* was a misprint; it was intended to allude to the peculiar bifarius arrangement of the leaves in luxuriant plants." It will be seen from the above that the type specimens of *taxifolia* were collected on the Blue Mountains, but whether all the specimens of Don or Schauer belong to *taxifolia* of Cunningham, is very questionable, as in Don's work, *l.c.*, it is mentioned as "a decumbent shrub," and in Schauer's work, *l.c.*, the leaves are said to be "laxe fasciculatis," or loosely fascicled.

Having examined a large amount of material both in the field as well as the abundant collections in the Herbarium, from a fairly wide range of country, I am inclined to believe that the descriptions given above as well as that given by Bentham, are of a composite character, as the material in the herbarium may be divided into three if not four distinct varieties. Allan Cunningham evidently thought there were three species in New South Wales, as we find that he proposed the name *D. intermedia* (vide Schauer in Nov. Act. Nat. Cur. XIX, Suppl. ii, 190 (1840) and Walp., Repert. ii, 154 (1843). In the latter work, however, it is included

[1] Schauer also gives a fuller description which seems to be of a composite nature so as to include both *D. taxifolia* and *D. intermedia* of Cunningham.

as a synonym of *D. laxiflora* (which as mentioned above was mistaken as a misprint), but curiously enough Nova Hollandia occidentalis is given as the habitat. In Index Kewensis *D. intermedia* A. Cunn. is given as a synonym of *D. taxifolia* A. Cunn.

Cunningham's *D. intermedia* is a New South Wales plant and I have endeavoured to define the Blue Mountain plants from the Port Jackson forms in the following way:—

D. taxifolia A Cunn. *typica.*

Usually more or less upright or spreading shrubs. Leaves falcate with mucronate tips and distinctly but minutely petiolate. Flowers 5 mm. long, white, pink, or occasionally tinged green, usually 4 together in the axils of the upper leaves, supported by two bracts which are of a reddish colour. Bracts 6 to 7 mm. long, equal in length or slightly exceeding the flowers, with scarious margins, having a prominent nerve through the centre, ending in a distinct soft mucronate-like point. Calyx tube 5 to 6 mm. long, with 5 distinct ribs, rugulose between the ribs in the lower part, and comparatively smooth upwards, with petal-like lobes. Petals scarcely distinguishable from the calyx-tube. Anthers 10, alternating with minute subulate staminodia.

Distribution as follows:—Clyde W. Baeuerlen; Jervis Bay, J. H. Maiden; Bowen Island, Dr. F. A. Rodway; Katoomba, W. Forsyth; Blackheath, R. H. Cambage (No. 1208); Mount Wilson, J. Gregson.

Darwinia taxifolia A. Cunn. var. *biflora* nov. var.

D. taxifoliæ similis sed floribus solum duobus.

The plants which I propose to record under the above varietal name are very similar to the typical *D. taxifolia* from the Blue Mountains, but the flowers are slightly larger, the bracts obtuse, and not longer than the flowers, and only two together on the tips of the branches instead of four as in the typical form. Specimens in the National

Herbarium, Sydney, which may be referred to this variety are from the following localities:—Beecroft, E. G. Jacobs; Hornsby, W. F. Blakely and D. W. Shiress; Peats Ferry Road, H. Deane; Tumble-down Dick, W. F. Blakely; Cowan A. A. Hamilton, J. L. Boorman, and R. H. Anderson. There are also specimens from Linden to Woodford, Mr. A. A. Hamilton, which seem to belong to this variety rather than the typical *taxifolia*.

D. taxifolia A. Cunn. var. *grandiflora* Benth. B.Fl. iii, 12.

Through the kindness of W. Laidlaw, B.Sc., and Mr. J. R. Tovey of the National Herbarium, Melbourne, I have been able to examine the original specimen of the above variety collected in the Illawarra district. We have in the National Herbarium specimens from West Dapto, R. H. Cambage, and Cataract Dam, J. H. Maiden, which are identical with the specimen recorded by Bentham, *l.c.* Cataract River, J. H. Maiden and E. Cheel; West Dapto, R. H. Cambage (No. 415); Mooney Creek, Gosford, Miss Brewster. The Cataract River specimens collected by Mr. Maiden have rather larger flowers of a rich purple colour and a longer style (10 mm. long) than the other collections, and may be the var. *grandiflora* of Bentham.

Darwinia taxifolia A. Cunn., var. *intermedia*. Syn. *D. intermedia* A. Cunn. ex Schauer in Nov. Act. Cur., XIX, Suppl. ii, p. 190 (1810); *D. taxifolia* Baker and Smith, this Journ, XXXIII, 163 (1899) non A. Cunn.

Ramis decumbentibus. Foliis linearibus falcatis acininformis triquetris apice mucronatis, densissime congesti apicibus ramis vel plus minus fasciculatis. Flores terminales sex.

The habit of this plant is quite distinct from the typical *D. taxifolia* common in the Blue Mountains as will be seen from the following description. The leaves are similar in shape but are more congested, especially towards the tips

of the numerous branchlets, and are not so distinctly opposite or as bifarious as in the typical *D. taxifolius* or the var. *biflora*. The bracts are also shorter than the flowers whereas in all other forms they are equal in length or slightly exceed the flowers.

Diffuse or decumbent shrub, branches rarely more than two to three feet long, the branchlets being more or less shortened and crowded. Leaves crowded, more or less fascicled, and not so distinctly opposite as in *taxifolia* and *grandiflora*, falcate and distinctly triquetrous, acute but not mucronate as in *D. taxifolia;* the petiole less distinct, the base decurrent on the branches and uniform in colour with the articulation.

Flowers usually 6, crowded together at the extremity of the branchlets in the axils of the leaves. Bracteoles acutely keeled, 4 mm. long, two-thirds as long as the flowers; calyx 5 – 6 mm. long, with five prominent ribs, slightly rugose between the ribs in the lower part, the lobes orbicular, petaloid, slightly ciliate. Petals scarcely distinguishable from the calyx-lobes.

Anthers 10, with distinct but minute filaments, alternating with minute subulate staminodia.

Style protruding beyond the apex of the corolla about 5 – 6 mm. and in this respect slightly exceeding that of *D. taxifolia*.

Specimens in the National Herbarium are from the following localities:—Botany swamps and Coogee, E. Betche; Centennial Park, W. Forsyth and E. Cheel; Loftus, J. H. Camfield and A. A. Hamilton; Heathcote, A. A. Hamilton and E. Cheel; Cronulla, E. Cheel.

Darwinia grandiflora Baker and Smith, this Journal, L, 181, 1916; *D. taxifolia* var. *grandiflora* Baker and Smith, *ibid.*, XXXIII, 164, 1899, and Cheel, Proc. Linn. Soc. N.S.W., XXXVII, 393, 1912.

This species was originally referred to by Messrs. Baker and Smith who state that "it occurs in a very luxuriant

form at Berowra." In 1912, a note was published by myself, *l.c.*, stating that the plants were "upright shrubs from four to seven feet high." It is more fully described by these gentlemen from plants collected from the same locality as those collected by Dr. J. B. Cleland and myself and recorded as above. The localities are as follows:—Berowra, A. A. Hamilton; W. F. Blakely and D. W. C. Shiress; Hawkesbury River, opposite Milson Island, E. Cheel and Dr. J. B. Cleland. Specimens from the same locality collected for and distilled by Messrs. Baker and Smith; Cowan, W. M. Carne and W. F. Blakely.

Homoranthus A. Cunn.

H. virgatus A. Cunn. ex Schau. Linnæa, x, 310 (1835); Monog. Myrt. Xeroc. Sectio I, 193, tab. 3 A. (1840); Walp. Repert. ii, 154 (1843) et v, 729 (1845-6); B. Fl., iii, 16 (1866); *Enosanthes virgatus* A. Cunn. in Nov. Act. Nat. Cur. XIX, Suppl. ii, 193 (1840); *Darwinia virgata* F.v.M., Fragm. IX, 176 (1875); Key to Syst. Vict. Pl. i, 259 (1887).

The descriptions of both Mueller and Bentham are composite, to include the two species, but from my own observations in the field in the neighbourhood of Broadwater, Richmond River, N.S.W., and examination of material in the National Herbarium, this species may be described as follows:—

Slender upright virgate shrubs about four feet high. Leaves opposite, semiterete, about 1 cm. long, not crowded, the oil glands not so prominent and the colour less glaucous or of a more greenish colour than in *H. flavescens*. Flowers solitary in the axils of the leaves along the upper parts of the branches, but not crowded. Style short.

Distribution:—The localities Richmond River, Cape Byron and Moreton Island mentioned by Mueller (Fragm. IX, 176) and Islands of Moreton Bay, and probably also Cape Brown, mentioned by Bentham (B. Fl. iii, 16) are districts in which this species is

usually found, and to the above specimens in the National Herbarium, Sydney, are represented as follows:—Wardell, Richmond River, E. Betche and Rev. W. W. Watts; Byron Bay, W. Forsyth; East Ballina, W. Baeuerlen (No. 458) and Rev. W. W. Watts; Broadwater, Richmond River, E. Cheel; Tweed River, W. Forsyth; Coffs Harbour, J. L. Boorman; Stradbroke Island, Queensland, C. T. White. I have not seen the specimens collected at Mudgee by Woolls (F.v.M., Fragm. IX, 176), and suggest that they probably belong to *H. flavescens*.

H. flavescens A. Cunn. ex Schau. in Linnæa X, 310 (1835); Myrt. Xeroca. i, 192, t. 3 B. (1840); Walp., Repert. ii, 154 (1843); B. Fl. iii, (1866); *Enosanthes flavescens* A. Cunn. ex Schau., Nov. Act. Acad. Cæsar. Leop. Carol. XIX, Suppl. ii, 192, t. 3 (1840).

The following is a description given by Walpers, *l.c.*, "Ramis decumbentib.; foll. incurvis fasciculato-confertis claviculata acerosis, a lateribus compressis."

This is united with *H. virgatus* as a synonym by Bentham *l.c.*, and Mueller *l.c.*, but the decumbent habit and crowded leaves and other characters seem to me to render it sufficiently distinct, to regard it as a distinct species. From the collector's notes and abundant herbarium material it may be described as follows:—

A low decumbent shrub usually attaining a height of about 1½ feet, but spreading several feet on the ground. Leaves slightly shorter than those of *H. virgata* and more or less linear-triquetrous falcate, crowded, especially on the short branchlets; oil-glands very prominent, the whole aspect of the plant being of a glaucous or silvery appearance. Flowers on very short but distinct pedicels, crowded towards the tips of the branchlets in the axil of the leaves. Sepals and petals similar in shape and size, but of a yellowish colour and more viscid, and the style longer than those of *H. virgata*.

Distribution, Northern Half of New South Wales. Forest lands skirting Liverpool Plains and Molle's Rivulet below Wellington Valley, A. Cunningham; and to the above, specimens from the following localities may be added:—Coonabarabran, Rev. M. Curran and W. McDonald; Timor Rock, J. L. Boorman; Quirindi, W. McDonald; Cubbo to Wongan and Bohena Creek to Boggabri, Dr. H. I. Jensen (Nos. 53 and 55); Pilliga, Forester E. H. Swain and W. A. de Beuzeville; Currabubula, R. H. Cambage (No. 3561), Narrabri West and Nandewar Range, J. L. Boorman and G. Burrow; Howell, J. H. Maiden and J. L. Boorman; described as "Prostrate, silver-leaved and secund, on faces of bare rocks, sometimes spreading to 20 feet;" and recorded in Journ. Linn. Soc. N.S.W., XXXI, 68 (1906) as *Darwinia taxifolia*. Inverell, H. Deane and J. L. Boorman.

Homoranthus darwinioides nov. comb.

Verticordia darwinioides Maiden and Betche, Journ. Linn. Soc. N.S.W., XXIII, 17, 1898; *Rylstonea cernua* R. T. Baker, *ib.*, 768. Dubbo, J. L. Boorman; Mount Corricudgy, R. T. Baker.

Homoranthus Wilhelmii nov. comb.

Verticordia Wilhelmii F.v.M., in Trans. Vict. Inst. 122 (1855); B. Fl., iii, 19, (1866), Boston Point, Port Lincoln, S.A., C. Wilhelmi and W. Gill.

NOTES ON MELALEUCA LINARIIFOLIA SM., AND M. TRICHOSTACHYA LINDL.

By EDWIN CHEEL,

Botanical Assistant, Botanic Gardens, Sydney.

[*Read before the Royal Society of N. S. Wales, June 7, 1922.*]

IN my official investigations of various Myrtaceous plants I have found it necessary to make a close examination of the material grouped under *M. linariifolia* and *M. trichostachya*, on behalf of oil-distillers. Messrs. Baker and Smith state[1]:—

"Essential Oil.—The leaf oil of this species of Melaleuca (*M. trichostachya*) is of considerable commercial importance, as it is one of the richest in cineol content of any known essential oil."

A further statement, in the same paper (p. 594), reads—

"*M. linariifolia* appears to be more limited in its geographical distribution than *M. trichostachya* which extends over a wide area of country, as it occurs on the north-east coast of the continent and over the Main Divide to Cooper's Creek, a rather unusual range,—from the moist coast region to the arid interior, and yet is constant in character throughout."

In view of these statements, I have deemed it necessary to bring under notice the following particulars of the range of these species, which is not strictly in accord with that given by Messrs. Baker and Smith.

Melaleuca linariifolia Sm. in Trans. Linn. Soc., iii, 278 (1797); Exot. Bot. t. 56 (1804-5); DC., Prod. iii, 214 (1828); Link's Enum. ii, 273 (1822); Baker and Smith, this Journal XL, 65 (1906), and XLIV, 597 (1910) in part.

[1] This Journal, XLIV, 595, (1910).

The original specimens from which descriptions were drawn up by Sir J. E. Smith, were collected in the Port Jackson district, and although descriptions have been published by Bentham, *l.c.* and others, it seems advisable to give a detailed list of localities for this species:—

a. Young branches more or less minutely hairy. Morriset and Greta, J. L. Boorman; Prospect, R. H. Cambage (No. 3586); Thirlmere and Glenbrook, J. H. Maiden.

b. Young branches apparently quite glabrous. Conjola, W. Heron; Wingello, J. L. Boorman; Moss Vale, E. Betche; Hill Top, E. Cheel; Bargo, J. L. Boorman; Colo Vale, J. H. Maiden; Cobbity and Nepean River, J. H. Maiden; Little Bay, Sydney, A. A. Hamilton; Ryde, Parramatta River, W. F. Blakely; Wentworthville, near Parramatta, H. O. Rottan; Richmond, R. Helms; Glenbrook and Wentworth Falls, A. A. Hamilton; Mount Tomah, J. Gregson; Gosford L. G. Irby and C. F. Laseron; Wamberal, E. Cheel; Wyong (? collector); Bullahdelah, J. H. Maiden; Taree, H. G. Lloyd; Port Macquarie, C. F. Laseron, J. H. Maiden, and J. L. Boorman; Dorrigo, E. Swain.

Melaleuca trichostachya Lindley.

The original description is in Mitchell's Trop. Aust., 277, as follows:—

"Foliis saepius oppositis linearibus planis utrinque acutissimis, spicæ terminali laxiuscula rachi pilosa, calyce glabro dentibus herbaceis, phalangibus polyandris ungue petalis breviore."

The habitat given is sub-tropical New Holland, 1846 (No. 421). This number is quoted below. In his general remarks on this species Mitchell gives the following:—"Aug. 16th. There also grew in the sandy bed of the river a new white flowered *Melaleuca*, resembling *M. ericifolia*, but with long mucronate leaves."

Bentham (B. Fl., iii, 141) regarded it as a variety of *M. linariifolia*, and gives the following additional localities:— Belyando River (Mitchell), [probably the type locality of Lindley's plant]; Burdekin and Gilbert Rivers and along the N. E. Coast, F. Mueller; Cooper's Creek, Howitt's Expedition."

A. O'Shanesy (Proc. Linn. Soc. N.S.W., vi, 732, 737, 1881-82) evidently regarded it as a distinct species, for we find the following particulars given :—

"We crossed the Nogoa River half a mile from Emerald, in the bed and along the banks of which we noticed large trees of *Melaleuca trichostachya* . . . Myrtaceæ are well represented at Springsure . . . We also noticed *Melaleuca trichostachya*. . . ."

Mueller, Second Census, 94, (1889) also regarded it as distinct. Bailey (Ql. Fl. 600, (1900) and "Comprehensive Catalogue," 187 (1909) evidently followed Bentham *l.c.*, as he records as a *variety* of *M. linariifolia*, and refers to it as "Tee-doo" of Dunk Island natives."

In the National Herbarium, Sydney, we have a fairly large series of specimens which may be referred to this species including a portion of the original specimen collected by Lieut. Col. Sir T. L. Mitchell referred to above, and labelled Sub-Tropical New Holland, Camp 65, Broad Sunday River, Lieut. Col. Sir T. L. Mitchell (No. 421) 1846; Springsure, J. L. Boorman, ("A medium size small tree of 6—10 feet high growing in moist places near the banks of a permanent creek known locally as 'Tea-tree.' The only species of the genus in the district and fairly common"); Prairie, N.Q., J. R. Chisholm per R. H. Cambage (No. 4255); Mount Perry, J. L. Boorman, ("Perhaps a form of *M. linariifolia*, a fairly tall tree, flowers and fruits in distinct pairs in spikes 1--1½ inches long"); Boulia, F. M. Bailey ex Herb. Brisbane, Chatsworth Station, N.W.Ql., H. A. Long-

man; Banana Creek, Patrick Kehoe (No. 30); Mount Morgan, C. F. Henrichson; Maryborough District, J. E. Young ex Herb. Brisbane, labelled *M. linariifolia*. Also a specimen from Mount Morgan and Gladstone, Queensland.

It will be seen from the above that the species is chiefly confined to Central and Northern Queensland districts. F. v. Mueller *l.c.*, gives S. Australia, Queensland, and N. Australia. Messrs. R. T. Baker and H. G. Smith (this Journ. XLIV, 592, t. 47, 1910) give in addition to Gladstone, Queensland, Angledool, Gosford and Port Macquarie, three New South Wales localities. In June 1917, I wrote to Mr. Baker asking for a loan of specimens from the above mentioned New South Wales localities, and received specimens collected at Port Macquarie and Gosford, but none from Angledool. After a critical examination of the material forwarded by Mr. Baker collected at both Gosford and Port Macquarie by Mr. Laseron, I have no hesitation in referring the Port Macquarie and Gosford material to *M. linariifolia*. A specimen from Barwon River near Collarenebri collected by G. Burrow, is the only one so far seen from New South Wales referable to this species.

OBSERVATIONS RESPECTING SOME ESSENTIAL OILS FROM LEPTOSPERMUM LIVERSIDGEI.

By A. R. PENFOLD, F.C.S.

[*Read before the Royal Society of N. S. Wales, July 5, 1922.*]

THIS particular species of Leptospermum was first described in the Proceedings of this Society, Vol. XXXIX, (1905) page 124, by Messrs. Baker and Smith. The chemical and physical constants and composition of its essential oil, as then given, were as follows, viz:—

Percentage yield of oil	0·227%
Specific gravity at 15° C.	0·8895
Optical rotation	+ 9·2
Refractive index, 16° C.	1·4903
Citral	35%
Citronellal	not detected

The non-aldehydic portion of the oil was stated to consist of geraniol, and its acetic acid ester (about 15%), *d*-α-pinene (25%), sesquiterpene and undetermined (25%).

During the past few years the author has had occasion to examine a number of the oils distilled by himself from this shrub with somewhat variable results. These have been supplemented by the observation that upon crushing up the leaves between the fingers, both of herbarium specimens and of cultivated plants, totally distinct odours have been evolved, in some instances citral, and in others citronellal being readily detected. It is just possible that conditions of environment may be responsible for these differences, but some considerable time must elapse before such evidence, either for or against is forthcoming. Meanwhile, the writer is inclined to the conclusion that in all probability there are at least two distinct forms, and not unlikely three, of this shrub, viz:—

(*a*) One yielding an oil to the extent of 0·25 to 0·3%, as originally described, containing about 35 – 50% citral (no citronellal).

(*b*) A form yielding an oil, about 0·55%, containing 70 – 80% citronellal (no citral).

(*c*) A form yielding about 0·6 – 0·8% of oil containing about 70 – 80% citral (no citronellal ?).

As shown in appended table of experimental results, material has been obtained from Frazer Island, Queensland, which yielded essential oils in fair agreement with the composition of the oil as first described, whilst others collected at about the same time of the year, and in similar localities, yielded oils of different composition, as described above, see (*b*).

As the material in each case was determined botanically to be the species *Liversidgei*, and as it is a shrub that is generally considered to be comparatively easy of recognition, the above mentioned conclusion is practically the only one that could be arrived at at the present time. The author would have preferred to have extended these observations over a further period of years, supplementing same with field inspections, but thought it advisable to record the results obtained to date in view of their possible economic influence, for the following reasons, viz:—

(1) The distillation of the oil from *Leptospermum Liversidgei* (*a*) as originally described, cannot be considered an economic proposition for the preparation of citral, in view of its low percentage yield, 0·25%, and low content of aldehyde, only 35 – 46%. This probably accounts for its neglect in the past.

(2) The type (*c*) yielding about three times as much oil as (*a*), of high citral content, 70 – 75%, which would most probably be botanically diagnosed as (*a*) and thereby passed over, would most likely pay to distil. Good areas are

available, particularly in certain of the Northern River Districts of New South Wales.

(3) The same remarks apply here as under (2). For an oil yielding citronellal to the extent of 82%, free from other aldehydes, it is a noteworthy source of that constituent, especially on account of the ease of collection of the plant material. Provided sufficient material is available, it should be a serious competitor of the oil of *Eucalyptus citriodora*. In fact the two oils are identical in odour, and cannot be distinguished except by chemical examination.

Experimental.

The leaves and terminal branchlets of this species, cut in all instances as for commercial distillation, yielded the following essential oils, which are best shown for purposes of comparison in tabular form, on page 85, viz:—

The oil containing 82% citronellal obtained from material collected at Woodburn, N.S.W. was more closely examined with the following result; on distillation at 10 mm. the crude oil yielded the following fractions:—

Boiling point °C. at 10 mm.	Percentage by volume.	Specific gravity $\frac{15°}{15°}$ C.	Optical rotation, °	Refractive index 17½°C.
59 – 84	13	0·8677	+20·3	1·4591
84 – 87	20	0·8717	+10·7	1·4566
87 – 90	36	0·8744	+ 8·8	1·4567
90 – 95	15	0·8802	+ 8·5	1·4598
95 – 110	9	0·9069	+11·25	1·4748

Determination of the Terpene.—The fraction of boiling point 59–84° C. at 10 mm. was treated with sodium bisulphite solution to remove the aldehyde. The unabsorbed oil amounting to about 50% of the volume boiled at 156–160° C., had optical rotation +36·8°, and refractive index at 17° C. 1·4667. On mixing with an equal volume of lævo-alpha-pinene of $[\alpha]_{D\ 20°\ C.}$ −50·18° it readily gave a copious yield of nitrosochloride, which after purification, melted and decomposed at 109° C. The terpene, therefore, appears to be mainly *d*-α-pinene.

Date.	Locality.	Percentage Yield of Oil.	Specific Gravity at 15° C.	Optical Rotation.	Refractive Index 20° C.	Solubility in 70% Alcohol.	Aldehyde Content		Remarks
							Citral	Citronellal	
				°			%	%	
May 1918	Broadwater, New South Wales	0·8	0·8960	+6·2	1·4854	1 in 1·5 vols	75	...	type (*c*)
Nov. 1918	Forestry Depart. Brisbane	0·5	...	...	...	...	...	70	type (*b*)
March 1921	Frazer Island, Queensland	0·25	0·8885	+12·10	1·4822	insol in 10 vols.	46	..	type (*a*)
April 1921	Ditto ditto	0·33	0·8905	+12·75	1·4820	Ditto	46	...	Ditto
May 1922	Woodburn, New South Wales	0·55	0·8826	+11·2	1 4603	1 in 1·5 vols	...	82	type (*b*)
June 1922	Crescent Head, N. S. Wales	0 6	0·8910	+7·25	1·4832	Ditto	70 (Aldehydes by bisulphite method 74%).	?	type (*c*)

Determination of the Aldehyde.—The fraction of boiling point 87 – 90° C. at 10 mm. resembling citronellal was used directly for the preparation of the β-napthocinchoninic acid derivative and the semicarbazone, both of which were readily obtained. The former melted at 225° C., and the latter, after re-crystallisation from chloroform and petroleum ether, at 82·5° C., thus proving the aldehyde to be citronellal.

The fractions of boiling point 84 – 87° C., and 87 – 90° C. at 10 mm. were mixed and combined with sodium bisulphite solution. After purification the solid bisulphite compound was decomposed by means of sodium carbonate, and steam distilled, when a very poor return of citronellal was obtained. As thus obtained it possessed the following characters:—

Boiling point at 10 mm.	88 – 89° C.
Specific gravity $\frac{15°}{15°}$ C.	0·8569
Specific rotation $[\alpha]_{D\ 20°\ C.}$ ...	+12·56°
Refractive index, 19° C.	1·4468
Semicarbazone, melting point ...	78 – 79° C.

Judging from the melting points of the semicarbazones, the aldehyde appears to consist of a mixture of the two isomers. Citral was not detected.

Determination of presence of other constituents.—The higher boiling fractions were heated with phthalic anhydride but no free alcohols, such as geraniol or citronellol, were detected. After removal of the aldehyde, the other dextrorotatory constituent was found to be a sesquiterpene, which gave the usual colour reactions for such bodies usually occurring in the essential oils of the Myrtaceæ.

Determination of a Paraffin.—From the residue left after distillation a saturated paraffin was isolated of melting point 62 – 63° C.

This particular essential oil, therefore, consists of citronellal (82%), the remainder being *d*-α-pinene, sesquiterpene, paraffin, and probably a little ester.

I have to thank Mr. E. H. F. Swain, Director of Forests, Brisbane, and Mr. F. C. Epps, Forest Ranger of Frazer Island, Queensland, for kindly furnishing the excellent supply of leaves from that locality; also Messrs. Gillard Gordon Limited, Sydney, for permission to publish the results from material collected at Broadwater. My thanks are likewise due to Mr. F. R. Morrison, Assistant Chemist, for much help in the investigation, and Mr. C. F. Laseron, the Museum collector, for the material from Woodburn, New South Wales.

PRELIMINARY NOTE ON A NEW STEAROPTENE (PROBABLY A PHENOL ETHER) OCCURRING IN SOME ESSENTIAL OILS OF THE MYRTACEÆ.

By A. R. Penfold, F.C.S., and F. R. Morrison.

[*Read before the Royal Society of N.S. Wales, July 5, 1922.*]

In the course of investigations at present being undertaken in this laboratory on the essential oils of Australian plants, we have observed the presence of a solid constituent of high melting point in a number of those belonging to the N.O. Myrtaceæ, varying from traces up to about 6%, which apparently has not been previously observed or recorded. So far, those oils yielding this constituent in greatest amount are the essential oils of *Bœckea crenulata* (5·5%) and *Darwinia grandiflora* (2%). The examination of these two oils is proceeding, and the results will be communicated to the Society in papers to be presented later. We have thought it advisable to record the occurrence of this interesting substance, together with a note of its characters

determined to date, anticipating to find later in our research an oil yielding it in greater quantity to enable a more thorough investigation to be undertaken.

It is volatilised with difficulty in steam, and is, therefore, usually obtained at the termination of the distillation of the oil from the leaves and terminal branchlets in much the same way as eudesmol. If present in very small amount in the oil it is found concentrated in the residue after rectification.

Properties of the Stearoptene.

The crude solid material obtained at the termination of the distillation of the leaves of *Bœckea crenulata*, and from the residue left after rectification of the oil of *Darwinia grandiflora* was dissolved in boiling alcohol, from which it was obtained upon cooling in primrose-yellow needles of melting point 103 – 104° C.

It is readily soluble in hot alcohol, hot ether, acetone, xylene, chloroform, and benzene; moderately soluble in ethyl acetate, and very sparingly soluble in petroleum ether.

By crystallisation from alcohol it is obtained in monoclinic prisms. Its solution in alcohol was found to be optically inactive.

The formula appears to be $C_{13}H_{18}O_1$, as indicated by the following combustion and molecular weight results, viz:—

1. (B) 0·1078 gram gave 0·2578 gram CO_2 and 0·0738 gram H_2O. C—65·22%, H—7·60%.
2. (B) 0·1241 gram gave 0·2976 gram CO_2 and 0·0806 gram H_2O. C—65·4%, H—7·22%.
3. (D) 0·1136 gram gave 0·2728 gram CO_2 and 0·0793 gram H_2O. C—65·493%, H—7·756%.
4. (D) 0·1194 gram gave 0·2846 gram CO_2 and 0·0828 gram H_2O. C—65·01%, H—7·7%.
5. (D) 0·1106 gram gave 0·2658 gram CO_2 and 0·0770 gram H_2O. C—65·54%, H—7·73%.

6. (B) 0·1118 gram gave 0·2666 gram CO_2 and 0·0742 gram H_2O. C—65·04%, H—7·37%.
7. (B) 0·1164 gram gave 0·2792 gram CO_2 and 0·0794 gram H_2O. C—65·41%, H—7·58%.

$C_{13}H_{18}O_4$ requires C=65·55%, H=7·56%.

Molecular Weight Determinations.

(*a*) A molecular weight determination by the Landsberger boiling point method using acetone as solvent gave the following result:—1 gram in 28·25 c.cs. acetone elevated the boiling point 0·33° C. M.Wt. 238·7.

(*b*) A determination by the cryoscopic method using benzene resulted as follows:—0·2138 gram in 10·42 grams benzene lowered the freezing point of the solvent 0·43° C. M.Wt. 238·6.

$C_{13}H_{18}O_4$ requires 238.

Determinations of Methoxy Groups.

The percentages of methoxyl (OCH_3) obtained in three Zeisel determinations were 24·5, 25·4 and 26·2. $C_{13}H_{18}O_4$; $2\,CH_3O$ requires OCH_3 = 26·05%.

Judging from these estimations the stearoptene contains two methoxy groups.

As the total amount of material at our disposal was so small, amounting to but 12 grams, we were unable to proceed further with the elucidation of the chemistry of this beautifully crystalline substance, and, therefore, defer the matter of suggesting a name for it until we succeed in discovering better sources of supply, which will then enable us to determine its molecular structure as well as its other characters, and confirm or otherwise our surmise that it is probably a phenol ether.

A CHEMICAL AND BACTERIOLOGICAL STUDY OF A TYPICAL WHEAT SOIL OF N. S. WALES.

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[*Read before the Royal Society of N. S. Wales, July 5, 1922.*]

Introduction.

The object of the investigation was to get some insight into the bacterial activity, and more particularly the rate of nitrification at different seasons of the year in a typical soil from the wheat belt of New South Wales under varying systems of cropping and soil-management. The results were expected to throw some light on the failure of nitrogenous fertilizers to increase the yield of wheat on soils which, compared with those of other countries, are deficient in nitrogen. The soil, or rather soils, selected were from the Wagga Experiment Farm, and they are typical of much of the wheat land on the south-western slopes.

Samples were taken at monthly intervals from three different positions of the farm, from June 1921 to March 1922 inclusive, and the following estimations made, viz.:—

(1) A chemical and physical examination of the soils.
(2) Monthly determinations of the soil moisture.
(3) Monthly bacterial counts.
(4) Monthly determinations of the amounts of nitrate nitrogen in the soil and subsoil.
(5) An estimation of the nitrifying power of the soils at different periods of the year.

The samples were taken from—

(*a*) Virgin grass land, described in text and tables as "grass."

(*b*) A field till quite recently cropped with lucerne, on which barley was growing during the earlier months of the investigation, designated "lucerne." This soil has a different physical constitution from the other soils. (See Table I.)

(*c*) Experiment plots under rotation including—

(1) An uncultivated fallow—P A.

(2) A wheat plot, the straw to be left on the plot and ploughed in after harvest—P B.

(3) A cultivated fallow—P C.

(4) A wheat plot, the straw to be burned off after harvest and the land to be ploughed soon after–PD.

Owing to climatic conditions neither of the wheat plots had been ploughed when observations came to an end.

Sampling.

The June samples were taken to a depth of 6 inches with a spade and trowel, but for all later bulk samples a post-hole auger was used and samples taken to a depth of 9 inches and 9 to 18 inches, while 18 to 27 inches sections were taken in July and August. In June all the samples from the experiment plots, which up to that time had received the same treatment, were taken together, and in July the two fallow plots were treated as one, and the two wheat plots as one, but from August onward each plot was sampled separately. Special samples were taken in sterile glass tubes for the more delicate estimations. The actual dates of sampling were:—14/6/21; 14/7/21; 17/8/21; 15/9/21; 13/10/21; 16/11/21; 15/12/21; 11/1/22; 15/2/22; 16/3/22.

Physical Examination of Soils.

Mechanical analyses were made of the soils designated "grass" and "lucerne," and of a bulk sample from the experiment plots. The method employed was the simple elutriation method with two amplifications for separating—

(*a*) coarse and fine sand. (*b*) silt and clay fractions.

The three analyses of the surface soil are presented in in Table I.

Table I.—*Mechanical Analysis of Soils used in Experiment.*

Fraction.	Size of Particles.	Experiment Plots.	Lucerne.	Grass.
	mm.	%	%	%
Coarse gravel	6 – 2	·5	4·2	·6
Fine gravel ...	2 – ·5	10·5	25·5	7·4
Coarse sand...	·5 – ·1	9·5	11·3	9·75
Fine sand ..	·1 – ·04	27·5	26·0	30·75
Silt	·04 – ·01	19·5	15·5	51·5
Clay, etc. ...	below ·01	32·5	17·5	

This table confirms the results of field observations. The "lucerne" soil would be described as a sandy loam with a rather porous subsoil, while the grass land and experiment plot soils are heavy red clay loams with a retentive clayey subsoil. All are derived from granite, but the "lucerne" soil is near the top of a rather steep slope, whilst all the others are on gently sloping land further down. It is evident that a considerable amount of the clay has been washed out of the "lucerne" soil leaving a relatively high proportion of gravel and coarse sand.

Chemical Examination of Soils.

From a chemical point of view the soils are not very rich in plant-food-material, but are known to be sufficiently well supplied with everything except phosphoric acid for the successful growth of wheat under the climatic conditions of the wheat-belt.

Some chemical estimations by the usual analytical methods yielded the following results:—

"Lucerne" Soil.	Per cent.	Experiment Plot Soil.	Per cent.
Hygroscopic moisture	·91	Hygroscopic moisture	1·96
Loss on ignition ...	2·92	Loss on ignition ...	4·38
Insoluble matter (Conc. HCl)	93·35	Insoluble matter (Conc. HCl)	88·57
Lime—CaO	·11	Lime – CaO	·15
Phosphoric Acid ...	·12	Phosphoric acid ...	·08
Humus...	·93	Humus	·9

Temperature and Moisture Conditions.

The winter of 1921 was sufficiently wet to keep the soil more or less moist and sticky, the evaporation being at a minimum. A short wet spring was followed by a dry spell which gave the soil a good dessicating for two full months (November – December), and it has not really recovered from this till recently. We may note that maximum air temperatures averaged as follows:—
June 44°; July 45°; August 46°; September 54°; October 61°; November 78°; December 84°: January 87°; February 91°.

The rainfall averages were as follows:—
1918, 18·55 inches; 1919, 15·16 inches; 1920, 22·43 inches; 1921, 20·26 inches. 1921 to June 14th, 1081 points; June 14 – 30th, 39 points; July, 68 points; August, 209 points, well distributed in month; September, 312 points, 220 points on 9th-10th September; October, 139 points, 95 points on 15th October; November, 10 points; December, 168 points, all between 21 – 26th December; January, 104 points 80 points January 13th; February, 95 points, 70 points February 18th.

Speaking generally the soil in June, July, August, September was decidedly wet, in November, December, February, March decidedly dry, and in October and January intermediate and good for sampling.

Soil Moisture.

Soil moisture is dependent on three things—the amount of precipitation, the evaporation, and the treatment of the soil. These are all illustrated in the series of figures presented in Table II. and the graph which accompanies it (Fig. 1). It is seen that the total soil moisture has varied from very high to very low figures bordering on hygroscopic moisture. While the continued wet conditions prevailed from June to September, the various soil treatments made no difference in the totals, but the dry spell beginning in

October and continuing to nearly the end of December, brought the level very low. Though the good fall at the end of the year raised the January figures, yet the February samples showed the lowest moisture figures for any month.

Table II.—*Moisture in Surface Soil—Per Cent. of Dry Soil.*

Date of Sampling	Grass	Lucerne	PA	PB	PC	PD
June 14, 1921	11·44	15·84	Average of PA, B, C, D = 15·44			
July 14	11·10	9·91	PA – C = 12·54, PB – D = 11·28			
Aug. 17	11·98	14·96	15·51	14·57	14·60	14·52
Sept, 15	14·08	14·59	17·80	19·04	16·63	19·42
Oct. 13	5·61	7·03	9·54	6·66	12·57	7·82
Nov. 16	3·34	2·12	6·66	5·90	9·88	4·38
Dec. 15	3·10	2·03	4·24	4·47	8·97	4·47
Jan. 11, 1922	3·87	3·60	4·05	5·65	7·81	5·29
Feb. 15	1·48	2·67	2·10	2·89	5·37	2·35
Mar. 16	1·95	3·27	2·59	3·08	4·66*	3·27

* Subsoil PC contained 12·64% moisture down to 18″ depth. Other samples quite dry, the best of them being Lucerne with 4·85%.

The "Lucerne" soil has shown its constitution in rapidly losing water and the sod land never rose as high as the cultivated soil through run-off, and it dries out very thoroughly when heated up. Of the other four plots the cultivated fallow has not succeeded in accumulating moisture as it ought because of non-cultivation at critical times, notably in October, November and January, but it has maintained a lead, and its subsoil was in a very much moister condition than any other plot. The uncultivated fallow baked hard, and, with the crop of weeds and odd wheat plants to help the sun, generally was near the bottom of the series. The two cropped plots were not unsatisfactory during the growth of the crop but fell away badly afterwards. Summing up, the grass and cropped plots were normal, the cultivated fallow too low and should

be holding say 8% water, while the dryness of the uncultivated fallow is an illustration of the need for a good mulch on fallow land.

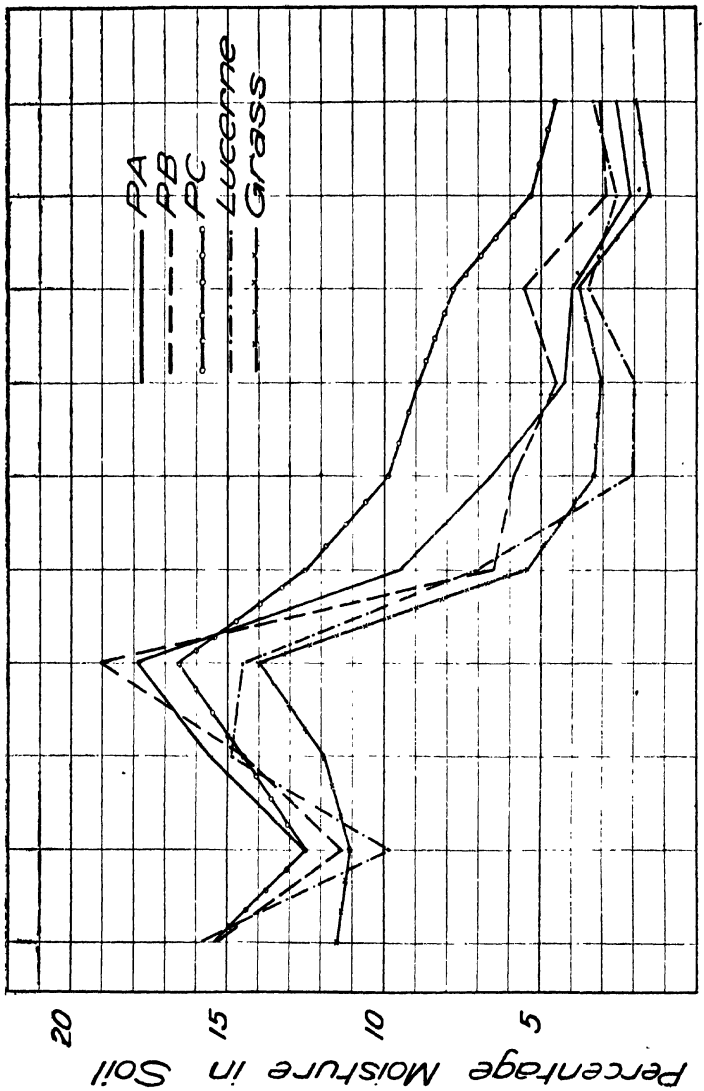


Fig. 1.

Bacterial Numbers.

Bacterial counts were made on standard agar neutral to bromthymol-blue. It was decided to continue with the medium since it is a very fair general one, though synthetic agars usually give higher counts. Its drawback was the constant occurrence of spreading colonies which were capable of overrunning a plate in 48 hours. Since a six-day period was made the basis of the counts serious losses occurred and caused gaps in the table of results. Table III. gives a skeleton picture of the variations in numbers.

The numbers are probably averages for such a soil and are roughly comparable with other semi-arid soils.

Table III.—*Bacterial Count from June 1921 to March 1922 (in millions per gramme).*

Date of Sampling.	Grass	Lucerne	PA	PB	PC
June 14, 1921 ...	2·0	...	PA, B, C = 6·0		
July 14	...	...	3·75	5·75	3·75
Aug. 17	2·75	2·5	3·0	4·1	5·1
Sep. 15	2·65	2·71	2·4	3·9	5·0
Oct. 13	1·75	3·1	5·9	5·5	7·5
Nov. 16	...	3·05	...	...	...
Dec. 15	2·58	3·2	6·0*	...	9·0*
Feb. 15, 1922 ...	2·25	5·0	...	6·0	6·0
Mar. 16	3·1	5·6	6·0*	7·1	7·63

* Circum.

The following points are worth emphasising (1) The order of merit of the plots is fairly constantly as follows:—cultivated fallow, cropped plot, uncultivated fallow, grass-land. (2) The drying of the soil does not seem to vitally affect the total numbers and in summer they are considerably higher than in winter. (3) There was a distinct drop in the bacterial numbers between July and September. The soils from PA, PB, PC and probably from "Lucerne"

seem to show a decrease at the end of winter and beginning of spring. Unfortunately the counts were not carried into the winter of 1922 and so the extent of the drop in total numbers for the winter season was not found. Tentatively a depression in the winter months may be postulated extending into spring so long as the soil is in the sodden cold state it assumes in the wet colder months and then rising to more or less uniform levels in the hotter season.

Total Nitrogen.

A series of estimations were made of the total nitrogen in the various plots but it was found, as expected, that the variations from time to time were only such as might be due to sampling or experimental error. The following figures give the average result:—

Surface Soil:—Grass ·055%; Lucerne ·060%; PA ·067%; PB ·066%; PC ·061%; PD ·063%.

Subsoil:—Grass ·038%; Lucerne ·039%; PA ·038%; PB ·041%; PC ·043%; PD ·045%,

Judged by the usual New South Wales standards these percentages are merely fair.

Nitrate Nitrogen.

The results obtained for nitrate nitrogen during the ten months of the experiment have not given us a clear lead in solving the question of the nitrate supply to the wheat crop. The figures for the consecutive samplings are set out in Table IV, a double column showing parts per million and lbs per acre 9 inches of nitrate nitrogen.

All the estimations were made by the phenol disulphonic acid method on 100 grm. portions of the air-dry soil.

Several anomalies are evident notably for "Grass" in the months of September and December, but these are most probably due to contamination since occasionally sheep were driven across this paddock. From the rest of the

Table IV—*Nitrate Nitrogen in Surface Soil, June 1921 to March 1922.*

(As parts per million and lbs per acre 9 inches).

Date of Sampling.	Grass.		Lucerne.		PA		PB		PC		PD	
	p. pm	lbs per acre, 9″	p. pm	lbs per acre, 9″	p. pm	lbs per acre, 9″	p. pm	lbs per acre, 9″	p pm	lbs per acre, 9″	p. pm	lbs per acre, 9″
June 14, 1921	4·2	10·5	12·4	31·0	3·0	7·5	3·0	7·5	3·0	7·5	3·0	7·5
July 14	4·0	10·0	3·5	8·5	5·2	13·0	8·8	22·0	5·2	13·0	8·8	22·0
Aug. 17	3·8	9·5	8 4	21·0	2·0	5·0	2·0	5·0	2·0	5·0	2·0	5·0
Sept. 15	11·5	28·75	3·5	8·75	4·2	10·5	3·1	7·75	2·0	5·0	4·4	11·0
Oct. 13	2·0	5·0	3·75	9·5	3·7	9·3	2·0	5·0	3·6	9·0	2·0	5·0
Nov. 16	2·0	5·0	4·3	10·8	3·4	8·5	2·0	5·0	7·5	18·8	2·0	5·0
Dec. 15	24·7	61·8	4·3	10·8	3·5	8·75	2·2	5·5	3·4	8·5	2·0	5·0
Jan. 11, 1922	5·0	12·5	11·2	28·0	6·2	15·5	5·2	13·0	12·6	31·5	2·0	5·0
Feb. 15	8·2	20·5	11·5	28·75	7·3	18·3	5·2	13·0	8·2	20·5	3·8	9·5
Mar. 16	7·1	17·8	14·5	36·3	7·1	17·8	4·9	12·3	10·0	25·0	2·0	5·0

table this fact comes out sharply—that during winter and spring months there is a remarkably low average of nitrates present in the soil. It is true there is a spasmodic rise in four cases in September, but it was not till the end of the year that the real increase came. It must be remembered that the active growth of the crop would keep certain plots in check, but what can be said of the meagre increase in the cultivated fallow? The most striking feature is the sustained increase beginning on all soils between November and January, after the wheat crop is normally ripe. "Lucerne" plot shows up in a very interesting light, because of its low moisture content and different constitution.

It is not easy to compare other countries in respect of nitrate cycles for a year for the reason that weather conditions, soil composition and state, previous treatment and the impossibility of theorising on anything but an extended period of investigation raise a strong barrier to such comparisons. There are of course variations in nitrifying power in relatively small areas, and other workers even under similar climatic conditions are dealing with vastly different soils. The soil used is fairly typical of large areas on the South West Slopes, and that makes the comparison the more extraordinary. Hall in South Africa has published a list of monthly determinations for an average soil at the Potschefstroom Station which runs as follows:—

Parts per Million of Nitric Nitrogen.

	June	July	Aug	Oct.	Nov	Dec.	Jan.	Feb.	Mar.	Apr.	May
Cultivated Fallow	34·8	24·0	16·0	26·0	25·0	49·0	33	13*	7*	9	9
Teff	8·3	8·7	7·3	11·1	8·3	14·6	20	8*	14·5*	6·4	6·5

* Average of two determinations per month.

He reports further his highest figure for nitrate was 55 p. pm. at midsummer, when it may be added maximum temperature and precipitation give ideal conditions for the

accumulation. Buckman at Cornell, U.S.A., notes the big advantage gained by the cultivated fallow which stores 66 p. pm. nitrate nitrogen compared to 14 p.pm. in the cropped land. Lyon and Bizzell at Cornell, N.Y. have found under their humid conditions immense amounts present, at times between 200 and 300 p.pm., and the average for the four summer months at about 50 p.pm. These rather staggering figures have no parallel under our climatic conditions and with the soil used. The main features in Table IV are without doubt the comparatively small amounts of nitrate present in the soils under investigation, and the demonstration of the fact that the main activity of the nitrifying bacteria occurs in the summer months even despite the low moisture content of the soil.

Nitrates in Subsoil.

The greater part of the subsoil nitrates is probably derived from the surface soil through water action. Table V presents the figures for subsoil and there is little to comment on. The winter quantities average higher than the summer, and this is probably due to the heavy rainfall and the low evaporation.

Table V.—*Nitrate Nitrogen in Subsoil—9" to 18" as parts per million and* lbs *per acre 9".*

Date of Sampling.	Grass.		Lucerne.		PA		PB		PC		PD	
	ppm.	lbs.	ppm.	lbs	ppm.	lbs.	ppm.	lbs	ppm.	lbs.	ppm.	lbs.
1921												
July 14	18·0	45·0	3·5	8·75	7·2	18·0	7·8	19·5	7 2	18·0	7·8	19·5
Aug. 17	6·8	17·0	2·4	6·0	4·0	10·0	2·8	7·0	5·6	14·0	...	
No Subsoil samples taken from September to November.												
Dec. 15	...		2·8	7·0	3·7	9·3	2·1	5·3	6·6	16·5	...	
1922												
Jan. 11	...		2·9	7·5	3·6	9·0	2·1	5·3	5·2	13·0	...	
Feb. 15	...		2·0	5·0	2·3	5·8	2·0	5·0	2·2	5·5	...	
Mar. 16	...		2·5	6·3	2·4	6·0	2·0	5·0	2·4	6·0	...	

A more interesting table is the one giving lbs of nitrate nitrogen per acre 18 inches.

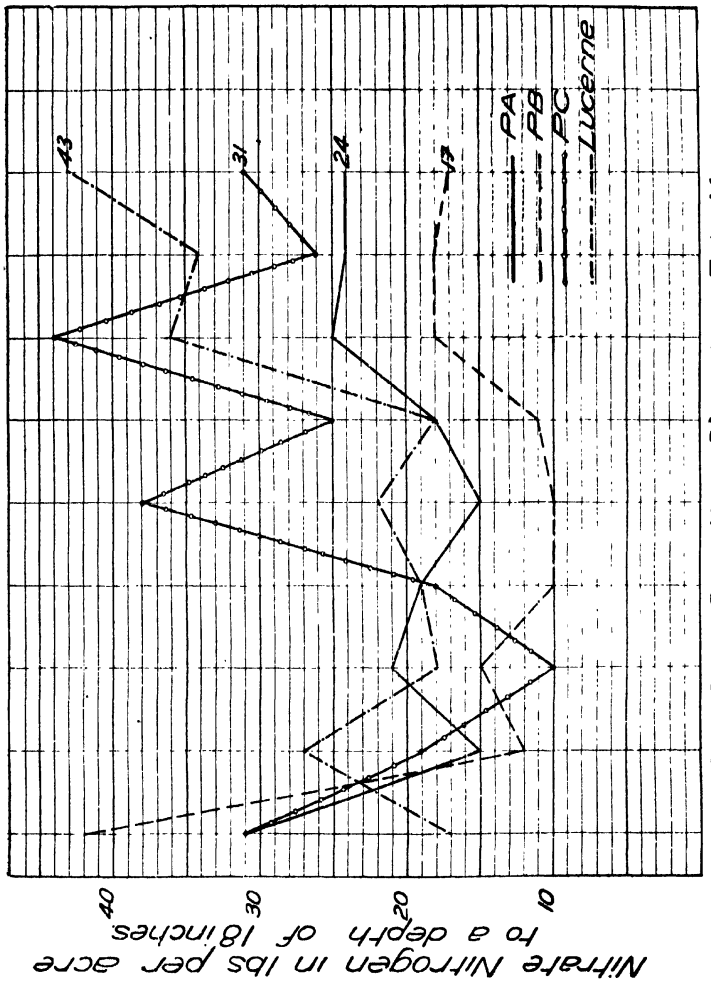


Fig. 2.

Table VI.—*Nitrate Nitrogen in pounds per acre to a depth of 18 inches.*

Soil.	July	Aug.	Sep.*	Oct.*	Nov.*	Dec.	Jan.	Feb.	Mar.
Lucerne	17	27	18	19	22	18	36	34	43
PA	31	15	21	19	15	18	25	24	24
PB	42	12	15	10	10	11	18	18	17
PC	31	19	10	18	38	25	44	26	31

* Since no subsoil samples were taken in September, October, and November the total has been got by doubling surface soil figures which would probably be to the advantage of those months.

The graph (Fig. 2) accompanying the table brings out its features more clearly, but it is unfortunate that the figures for September, October and November are approximate only. We seem however to have peaks in the curves at July – August and January. The cultivated fallow (PC) offers a puzzling variation by the fall in December. PA and PB are in close parallel and PC and "Lucerne" more or less agree as to curves. If we assume "Lucerne" to be slightly earlier than the others, then PA, PB and it are in no great opposition. Finally the magnitude of the curves is a disappointing revelation by the side of the results obtained in other countries.

Nitrifying Power of Soils.

It is generally assumed that the nitrifying power of a soil is a fairly constant figure; indeed the whole theory of judging fertility by nitrifying ability depends on this assumption. Now estimations of nitrification for the same plot at different times of the year leave room for difference in three places—first by sampling error, second by experimental error, third by real difference. Regarding sampling it can only be said that in all cases the soil was collected personally in exactly the same way with a soil auger. Then to test out experimental methods a small series was run using exactly similar methods and conditions. The

"beaker method" using 100 grm. portions of soil with 100 mgs. ammonium sulphate was employed and the nitrates estimated at the end of four weeks by the phenol disulphonic acid method. Two soils PB and PC were selected, and the nitrifying power estimated for December and March samples in March, using soil stored for three months in the case of the former. The check was to see if the same result could be obtained for the nitrifying power of PB and PC for December samples when estimated in December and in March. The result is shown in Table VII as per cent. of ammonium sulphate nitrified.

Soil.	December samples estimated in December.	December samples estimated in March.	March samples estimated in March.
	%	%	%
PB	27·7	26·4	17·0
PC	11·5	10·8	2·45

It appears that close agreement is obtained for the December samples when experimented with at different times, and we see that the March soil is evidently quite different in this particular from the preceding samples. In this case there only remains the hypothesis that the soil has a varying nitrifying power. To test this point the nitrifying powers of the monthly samples were estimated and assembled in Table VII.

Table VII.—*Percentage Nitrification of* $(NH_4)_2SO_4$ *—July 1921 to March 1922, inclusive.*

Date of Sampling	Grass.	Lucerne.	PA	PB	PC	PD
	%	%	%	%	%	%
July 14, 1929	18·4	19·1	25·0	24·0	25·0	24·0
Aug. 17	23·4	45·5	16·1	25·2	16·0	8·4
Sept. 15	12·4	27·1	18·5	22·6	...	...
Oct. 13	25·0	16·7	19·5	34·5	14·2	20·1
Nov. 16	17·2	11·6	32·4	22·8	13·7	23·7
Dec. 15	15·2	15·5	18·6	27·7	11·5	16·5
Jan. 11, 1922	26·4	17·9	30·2	32·1	33·5	19·8
Feb. 15	20·7	9·4	15·2	20·7	27·8	9·9
Mar. 16	17·2	9 0	14·9	17·0	24·5	14·1

Once again we are faced with a rise in January in all cases, but the table has a number of anomalies, *e.g.* the small figures for February and March with "Lucerne" soil are not correlated with the increase of nitrates (see Table IV). But if we accept this table as correct we are faced with the difficulty of saying why four plots side by side, two fallowed, two cropped, should in every case show a difference in nitrifying power sometimes very considerable. The writer believes the table sufficiently accurate to justify a complete experimental enquiry into the correctness of this hypothesis and as to the reason for the changes.

It was thought at times that different amounts of ammonium sulphate might alter these conclusions or might be more completely nitrified. In consequence 25, 50 and 100 mgs. respectively of the salt were added to the soil in the experiment and in another series ·2 grm. of dried blood were used, the incubation being four weeks with optimum water content at optimum temperature. The result is shown for two soils PB and PC in Table VIII.

Table VIII.—*Percentage Nitrification of* $(NH_4)_2SO_4$ *(using different concentrations) and of Dried Blood.*

Amount of $(NH_4)_2SO_4$ added.	PB		PC	
	December sample.	March sample.	December sample.	March sample.
	%	%	%	%
25 mgs.	71·6	64·0	52·8	67·6
50 mgs.	48·0	33·0	33·0	43·2
100 mgs.	26·4	17·0	12·3	24·5
·2 gm. dried blood	35·7	28 9	23·2	32·6

It is apparent that using the smallest amount of ammonium sulphate, the highest *percentage* of nitrification was obtained, but in no case was there a greater *quantity* of nitrate produced than with the 50 mg. additions. In the

case of 50 and 100 mg. additions the *total* amount of nitrate produced was approximately the same, and in one case the former gave a larger production of nitrate than 100 mgs. of sulphate of ammonia. With the dried blood it is interesting to note that in all four cases it yielded the highest amount nitrates. As a comparison it may be seen that whereas both 100 mgs. $(NH_4)_2SO_4$ and ·2 grms. dried blood contain apparently 20 mgs. nitrogen, yet the latter accumulates a far greater amount of nitrate nitrogen. From this it is worth noting that the soil we are dealing with has greater capacity for nitrifying dried blood than ammonium sulphate. Moreover, being a test of ammonifying power with the organic material, the writer would record it as necessary for future work on similar lines to include dried blood as one medium and 50 mgs. ammonium sulphate as a maximum for another. In every case in Table VIII with all amounts of medium the fact of variation in nitrifying power between the soil in December and March is confirmed.

There is one other point and a very important one. In the February soil samples PB were selected and used for a lime test. The soil was treated exactly as in the ordinary nitrifying test using 100 mgs. ammonium sulphate but ·5 grms. of CaO and ·5 grms. $CaCO_3$ were added to different lots in addition. It was found that the CaO caused an actual loss of nitrate compared to the check soils but the $CaCO_3$ gave a decided increase. Whereas the soil alone nitrified 20·7% of the ammonium sulphate added, the soil $+CaCO_3$ nitrified 36·8%. It was this result which brought out a suggestion that the soil *in situ* might be benefited both in physical constitution and in nitrifying power by an addition of lime. The objections are the expense and danger of a dry year, but the writer would maintain that an occasional dressing of lime specially in conjunction with a green crop would greatly benefit the soil provided a good winter fall of rain was obtained.

Soil Nitrogen.—The amount of nitrification of the soil's own nitrogen is important as showing the capacity of a soil to nitrify its reserve of complex nitrogen compounds and gives us an idea of what it is capable of doing with optimum field conditions. Reports from other countries show as much as 38% of this soil nitrogen nitrified and as little as a trace, but for average semi-arid soils the amount is roughly up to 6%. Hall at Potschefstroom reports an average of up to 5% for fifty-four soils, California from a trace to 26%, an average of 3—6%, Colorado 6% and so on. Granting now that the soil we are dealing with is typical of a large wheat district the amount of nitrification is quite low. The maximum amount for each soil is Grass, 2·2%; Lucerne, 2·8%; PA, 2·15%; PB, 2·2%; PC, 1·9%; PD, 1·8%; or in round figures 40 - 50 lbs nitrates in four weeks of optimum conditions.

Summary.

Some points of interest in the preceding pages may be tentatively emphasised not as indisputable facts but as useful for any continuation of this or similar experiments.

(1) Judged by the failure of the soil to respond to nitrogenous fertilisers, the crops grown on it are usually sufficiently supplied with nitrates. The experiments indicate, however, that it would be improved from a physical as well as a chemical and biological point of view, by liming and the introduction of organic matter.

(2) The moisture content is a lesson in fallowing. The cultivated fallow designated PC has not shown out as well as might be expected, but this was due largely to neglect to cultivate at a critical time, viz. October, November, and January. It is not improbable that with care and proper treatment not less than 8% could have been stored in the surface soil and the subsoil was shown in March to be holding 12% water. All the other soils were very low,

even down to 18 inches, and it is well seen to what limits a hot season can reduce soil moisture in soils under stubble or unprotected by a mulch.

(3) Bacterial numbers are just average and tend to rise to a more or less uniform level for the hotter months and sink to lower figures in the colder wetter months.

(4) In the table of nitrate content of the soil all the plots show a rise to some extent for January determinations. January then has been a good period for the conditions which assist the bacterial agencies in the soil. Further it seems that the hotter drier months favour the bacterial activities much more than say spring weather. November and December were warm months averaging for maximum atmospheric temperatures 78° and 84° respectively; January followed with an average maximum of 87° and it is well known that optimum temperatures for the work of these bacteria are 82° – 87°. We may assume that the surface soil is well heated up and is vastly different to say September. It happened that at Christmas time 1921 there fell 168 points of rain and high nitrate figures were obtained with the soils collected on 11th January, 1922. The favourable temperature and the addition of water caused the increase and the exceeding low limits of total moisture for February stopped the rise which was resumed in March. The increase shown in October – November might be considered as the skirmish which precedes the activity of the annual nitrification battle. There is no reason to doubt that if rain had fallen with the rise of temperature in November a different state of affairs would be seen in December, but the dessicating the soil received (only 10 points rain fell between October 22nd and December 21st) restricted bacterial activity. The amounts for August are inexplicable without more knowledge of the year's cycle, but we may conclude that the greatest nitrifying activity occurs in the summer

months provided rain falls to prevent extreme drying out, the activity probably beginning in November and reaching a maximum in December to February. Active nitrification follows a satisfactory moisture content and high temperature, and if these come together, nitrates can accumulate fairly rapidly, but we have not in the wheat belt of New South Wales the assured coincidence of maximum temperature and maximum rainfall.

(5) The question of the nitrifying power of our soils should be far more widely studied. Attention is drawn to the striking cases of varying nitrifying power shown in Tables VII and VII A.

(6) On the average the soil studied is far from being classed as a good soil from the nitrogen point of view at any rate, and even under optimum conditions it is incapable of accumulating large quantities of nitrates.

The writer regrets that he has been forced to abandon a scheme of investigation which with another twelve month's work would perhaps have given a better account of the story of New South Wales wheat soils.

Acknowledgment is due for direction and assistance to Professor R. D. Watt, Mr. G. Wright, Mr. A. H. E. MacDonald (Chief Inspector, Department of Agriculture), Mr. R. G. Downing (Chief Experimentalist), Mr. H. Ross (Manager of Wagga Experiment Farm), and the Experimentalist of the same Farm.

By the courtesy of Mr. G. Valder, Under Secretary for Agriculture, the field experiments were conducted at Wagga Experiment Farm.

THE MISCIBILITY TEST FOR EUCALYPTUS OILS.

By CHARLES E. FAWSITT, D.Sc., Ph.D., and CHRISTIAN H. FISCHER.

[*Read before the Royal Society of N. S. Wales, August 2, 1922.*]

THE technique of Eucalyptus oil testing has been well developed by H. G. Smith.[1] Among the tests for these oils the miscibility test has been found useful. The method hitherto used consists in a direct measurement of the amount of aqueous alcohol required to give a clear solution with a given volume of oil. It is possible, however, to carry out the test in a different way, and it occurred to us that these oils might be suitably tested in the same manner as the fixed oils and fats. In this method the oil (A) is mixed in definite proportions with a suitable liquid (B), say an aqueous alcohol, giving two layers of liquid at the ordinary temperature. The critical solution temperature is then determined by heating until only one layer is formed, and then allowing to cool until a cloudiness develops. The critical solution temperature (C.S.T.) has been found to alter considerably with slight changes in the composition of the oil, and so this method of testing the miscibility gives a more sensitive test than the other method in which the volume of aqueous alcohol required for complete solution of one volume of the oil is determined.

A method which is too sensitive may have disadvantages however. We have noticed that the changes in composition which Eucalyptus oils undergo say by exposure to the air or by distillation are liable to cause very marked changes in

[1] Baker and Smith, "Eucalypts and their Essential Oils," 2nd Edition Sydney, 1920.

the C.S.T. For example, a specimen of oil from *Eucalyptus Macarthuri* with a C.S.T. of 41° C. against a mixture of water and methyl alcohol was distilled and the last small portion discarded. The portion collected between 105° and 230°, amounting to at least 95% of the original, was tested in regard to C.S.T. against the same mixture of methyl alcohol and water as before distillation. The C.S.T. was found to be 63°, a rise of 22° as compared with the original oil. A specimen of oil from *E. polybractea* was distilled and all collected up to 200° C. Only a few drops of brown liquid were left in the distillation flask. The C.S.T. of the original oil was 47·5°. After distillation the C.S.T. was 59° C. To eliminate the effect due to varying proportions of water in the oil, the oil should either be dried before testing or else saturated with water. We have usually employed the latter method, leaving the oil in contact with water for at least twenty-four hours in a thermostat at 25° C. The adoption of this precaution still permits of other changes going on in the oil such as those due to the absorption of oxygen and polymerisation, to which such oils are particularly subject.

Method of Experiment.

The mixture, B, with which the oil, A, is heated, must be varied according to the class of oil. For most oils a mixture of water with methyl alcohol was used in these experiments. Other mixtures such as water and ethyl alcohol, methyl alcohol and ethyl alcohol, glycerine and methyl alcohol, and water and acetic acid have also been used. Although water-alcohol mixtures have been used here, it is not to be assumed that an alcohol mixed with water makes the most suitable mixture to test these oils with. While some oils after mixing with water and alcohol appear to retain the same C.S.T. for some hours, other oils such as those from *E. australiana* and *E. polybractea* show a rapidly altering C.S.T. This is shown by the following:

Table I.

A, Oil from *E. australiana*. B, 82% Methyl Alcohol and 18% Water.

Time after mixing.	C.S.T.
0	34·8° C.
3·5 hours	35·8
24 ,,	39·0
48 ,,	43
72 ,,	45·5
144 ,,	54·5

The change in C.S.T. must correspond to some molecular change in the solution, but we have not yet investigated this. It is probably due either to reaction between the cineol and the alcohol, or to condensation of the aldehyde present in the oil.

The method used was somewhat similar to that of Orton and Jones (Jour. Chem. Soc. 1919, *115*, 1055). In these experiments 1 c.c. of the oil, *A*, was mixed with 1 c.c. of the mixture of alcohol and water, *B*, in a small tube about 1 cm. in bore and 5 – 8 cm. long. The tube was drawn out somewhat at the open end, and fitted with a cap consisting of a piece of rubber tube and a piece of glass tube drawn out to a very small opening. This apparatus was then bound tightly by rubber bands to a thermometer, the liquid contents of the tube being placed exactly opposite the bulb of the thermometer. The thermometer and attachment were then placed in a large beaker containing water. The temperature was raised until the two layers of liquid mixed completely. The temperature (C.S.T.) at which a cloudiness developed on cooling was then noted. (The composition of the liquid B to be mixed with the oil should be chosen so that the C.S. Temperature is not too high, say not more than 60° C.; otherwise some of the constituents of B, such as alcohol, may be volatilised before the C.S.T. has been determined).

Results of Experiment.

In the tables given below are the results obtained by adding various substances to eucalyptus oil.

Table II.

A, Oil from *E. polybractea* (not specially dried or wetted).

B, Water 18%, Methyl alcohol 82% (by volume).

Addition to Oil. (Expressed in percentage by volume.)	C.S.T.
	36° C.
9·1 of oil from *E. amygdalina*	61·5° C.
9·1 of oil residue* from *E. dives* after distilling off the phellandrene	24·1° C.
9·1 of pinene	>75° C. (not miscible at 75° C.)
9·1 of cineol	32·4° C.
after saturating A with water	40° C.
after leaving A and B in contact for 5 hours	42° C.

The oils used subsequently to this were all saturated with water before being used.

Table III.

A = Oil from *E. Macarthuri*.

B = 79·5% Methyl alcohol and 20·5% water.

Addition to Oil.	C.S.T.
% 0	41·1
2·4 pinene	45·3
4·8 „	48·6
7·0 „	52·3
2·4 cineol	39·8
4 8 „	37·6
2·4 residue from *E. dives.**	38·5
4·8 „ „ ...	36·8
7·0 „ „ ..	34·9

* These same residues were used in II, III, IV, V, and VI.

Table IV.

A, Oil from *E. dives*, distilled in 1919.

B, 13·3% water 86·7% methyl alcohol.

Addition to Oil.	C.S.T.
% 0	34·0
2·4 pinene	37·7
4·8 „	41·5
7·0 „	45·6
2·4 cineol	31·5
7·0 „	25·0
2·4 *E. dives* residues ...	31·2
4·8 „ „ ...	26·5
7·0 „ „ ...	22·9

Table V.

A, Oil from *E. dives*, distilled in 1898.

B, Methylated spirits 91%, water 9%.

Addition to Oil.	C.S.T.
% 0	36·7
4·8 pinene	40·8
7·0 „	43·0
9·1 „	44·6
4·8 cineol	29·9
7·0 „	26·9
9·1 „	25·0
4·8 *E. dives* residues ...	31
7·0 „ „	27
9·1 „ „	24
4·8 *E. polybractea* oil ...	32·5
9·1 „ ...	28·6

Table VI.

A, Oil from *E. australiana.*

B, Acetic acid , water

Addition to Oil.	C.S.T.
% 0	37·2
9·1 pinene	54·2
9·1 *E. dives* residues ...	31 0
9·1 cineol	25·8

It will be seen from these measurements that a change in the composition by 1% pinene produces a difference in the C.S.T. of $1^\circ - 2^\circ$. As these temperatures can be read with an accuracy of about $\frac{1}{10}^\circ$ C., it will be understood that the method is a very sensitive one for the detection of differences in the composition of the oil.

Some physical determinations on oil, such as a determination of the density, are directly connected with the composition of the oil as determined by chemical analysis. For a substance like eucalyptus oil this 'analytical composition' is expressly what we want to know. The determination of miscibility and in particular of C.S.T. is not so directly related to the analytical composition, as to the true composition, in which all possible molecular complexes in solution play a part. A miscibility test does not appear therefore to have quite the same value for a eucalyptus oil as it has for some other mixtures, but the carrying out of this work has had its value in suggesting other avenues of research.

We are indebted to Mr. A. R. Penfold of the Technological Museum, Sydney, for supplying us with several samples of eucalyptus oil.

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ON THE AUSTRALIAN MELALEUCAS AND THEIR ESSENTIAL OILS, PART VI.

By R. T. BAKER and H. G. SMITH.

With Plate I.

[*Read before the Royal Society of N. S. Wales, August 2, 1922.*]

Introduction.

The two species upon which this paper is founded are *Melaleuca ericifolia*, Sm. and *M. Deanei*, F.v.M., both being found in Eastern Australia.

1. MELALEUCA ERICIFOLIA, Sm.

Botany:

This species was one of the first recorded from Australia being described by Dr. Smith in the Transactions of the Linnean Society, iii, 276, 1797, and a figure of it is given in Exot. Bot. t. 34. The diagnosis of this plant in Bentham's Flora Australiensis, Vol. III, p. 159, agrees very well with the botanical material upon which this paper is based, so that no description is here necessary. Bentham mentions a varietal form, viz.:—*erubescens.*

The chemical results, however, were not obtained from this red flowered form, but the plant with white flowers.

Geographical Distribution.

It is one of the widest distributed species of the genus, as Bailey records it from Queensland in his Flora of that State; Mueller for South Australia in his Second Census, whilst Robert Brown, Mueller and J. D. Hooker record it for New South Wales, Victoria and Tasmania respectively.

Chemistry of Essential Oil.

An essential oil was first distilled from the leaves and terminal branchlets of this Australian species of Melaleuca by Mr. J. Bosisto, (Proc. Roy. Soc. Victoria, July 1862).

Considerable investigation was undertaken about that time concerning some of the properties of this oil, such as its solvent action on resins, and for burning in lamps, (The Technologist 3, 1863, p. 17). Mr. Bosisto states that from 100 lbs of leaves and branchlets he obtained 5 ounces of a very limpid and almost colourless oil, partaking much of "cajuput" flavour; that with age it improved greatly giving more the aroma of the flowers. The specific gravity of this sample is recorded by him as 0·899.

In a paper on Essential Oils by Dr. J. H. Gladstone, (Journ. Chem. Soc., 17, 1864, p. 1) the constants for the oil of this Melaleuca are given. The specimen had been forwarded to London for display in the Exhibition of 1862, and with others was handed to Dr. Gladstone for investigation. The specific gravity recorded by him was 0·903 at 15·5° C.; refractive index $n_D = 1{\cdot}4712$; and rotation in a tube 10 inches long +26°—or corrected for 1 decimetre tube +10·23°.

Beyond the additional statement that the oil of *Melaleuca ericifolia* bears a striking resemblance to the "cajuput" of commerce, obtained from *Melaleuca leucadendron* of the Moluccas,[1] (The Technologist *loc. cit.*); and the remark by Dr. Gladstone, (Journ. Chem. Soc. 25, 1872, p. 1), "that the same oxidised compound as occurs in oil of "Cajuput" was evidently the principal constituent in the oil derived from *Melaleuca ericifolia*," nothing further appears to have been known as to the chemical properties of the oil of this Australian species.

It was thought desirable, therefore, that an investigation should be undertaken, so that the chemical composition and economic possibilities of the oil of this species of Melaleuca might be determined.

[1] Evidently *Melaleuca minor*, Sm. See Part V of this series of papers. This Journal 1913.

The knowledge concerning the chemical composition of oil of "cajuput" is now somewhat complete, and during recent years chemists have devoted considerable effort towards the elucidation of this problem. This question is more fully considered in Part V of this series of papers on the Australian Melaleucas and their oils, and an analysis given of a sample of oil of "cajuput," sent to us by Dr. M. Treub of the Royal Botanic Gardens, Buitenzorg, Java, (This Journal, 1913).

The elementary composition of the principal constituent in "cajuput" oil of commerce was correctly recorded as $C_{10}H_{18}O$ by Blanchet as early as 1833 (Annalen 7, p. 161). It was named cajuputene hydrate by Schmidl (Journ. Chem. Soc. *14*, 1862, p. 63). Dr. Gladstone named it cajuputol (Journ. Chem. Soc. *25*, 1872, p. 1). Its identity with cineol was shown by Wallach, (Ann. *225*, 1884, p. 315).

"Cajuput" of commerce is essentially a heavy oil, the specific gravity mostly ranging between 0·92 and 0·93; it is usually slightly lævorotatory, and contains an excess of 50 per cent. of cineol when determined by the phosphoric acid method. In addition to the cineol the aromatic alcohol terpineol is present in small amount, while the terpene pinene appears to be the lævorotatory form.

Although the oil of *Melaleuca ericifolia* contains both cineol and terpineol—the latter in the dextrorotatory form, yet, it can replace in no way the "cajuput" oil of commerce for pharmaceutical purposes, as the amount of cineol in the crude oil is less than 10 per cent., and the excess of terpenes, consisting of dextrorotatory pinene and dextrorotatory limonene, causes the specific gravity to be far too low for it to conform to official requirements for "cajuput." The somewhat large amount of terpineol which it contains gives to it a much more aromatic odour than possesses that of "cajuput," and in consequence it may be considered more

suitable for perfumery purposes than for medicine. Unfortunately the yield of oil is somewhat small, and the minute leaves, peculiar to the species, is also a character detrimental to profitable distillation. Another feature which may also militate against its industrial employment is the fact that commercially prepared terpineol can now be purchased at a comparatively cheap rate.

Summarising the results here recorded it may be stated that the oil of *Melaleuca ericifolia* differs from the oil of "cajuput" in the following directions:—

(*a*) by having a much lower specific gravity.
(*b*) by the terpenes being strongly dextrorotatory.
(c) by containing dextrorotatory terpineol in some quantity.
(*d*) by containing considerably less cineol, and
(*e*) by the chief oxygenated constituent being terpineol and not cineol.

Experimental.

The material for this investigation was collected at Kogarah, near Sydney, New South Wales, in February, 1916, and was from the white flowering form of this species. The yield of oil from the fresh leaves and terminal branchlets was 41 ounces from 306 lbs. of material, equal to 0·84 per cent. The crude oil was of a very light-amber colour, and had an odour with some resemblance to that of "cajuput," although more aromatic, a character due to the presence of the terpineol. This constituent being present in some quantity causes the oil to be less mobile than are, for instance, the majority of the cineol bearing oils of the Eucalypts.

The following constants were obtained with the crude oil:

Specific gravity at 15° C. = 0·8938
Optical rotation a_D + 13·3°
Refractive index at 20° = 1·4705.

The cineol was less than 10 per cent., and the oil was insoluble in 10 volumes 70 per cent. alcohol, but soluble in 1 volume 80 per cent. alcohol. The saponification number was 6·96 indicating 2·4 per cent. of terpinyl-acetate. The free alcohol was determined by boiling the oil for 1½ hours with acetic anhydride and anhydrous sodium acetate in the usual manner; the saponification number had then increased to 100·4. It is recognised, however, that acetic anhydride acts upon terpineol as a dehydrating agent, with the formation of dipentene and other bodies, and according to Heusler (the Terpenes, p. 259), the amount of terpinyl-acetate formed by the usual method of acetylating is about 84 per cent. of theory; if this statement is accepted as correct for the oil of this Melaleuca, then nearly 30 per cent. of free terpineol was present, assuming the whole alcohol to be that substance.

The slight colour of the crude oil was due to the phenol acting upon the iron of the digester during the process of distillation, and, in order to identify this substance, 178 grams of oil were agitated with dilute alkali in the usual manner; the phenol weighed 0·49 gram, equal to 0·27 per cent. The product was liquid and had an odour, and gave colour reactions with ferric chloride, somewhat closely resembling those given by tasmanol—the liquid phenol of Eucalyptus oils.

The test for aromatic aldehydes gave a negative result, the oil being agitated with a 30 per cent. solution of sodium bisulphite for several hours.

On rectification under atmospheric pressure 2 per cent. distilled below 168° (uncor.), consisting principally of water and volatile aldehydes. Between 168–190° 52 per cent. distilled; this fraction was colourless and consisted principally of dextrorotatory pinene (nitrosochloride melting at 103°); dextrorotatory limonene and dipentene (tetrabromide

melting at 109°), but contained cineol and some terpineol. Between 190–215° 26 per cent. distilled, the fraction consisting largely of terpineol. The temperature then rose considerably, and between 243–268° 15 per cent. distilled, the fraction consisting largely of a sesquiterpene.

The three main fractions gave the following results:—

	Sp. gr. 15°.	Rotation a_D	Ref. index at 28°
First fraction	0·8832	+14·3°	1·4628
Second ,,	0·8857	+11·5°	1·4650
Third ,,	0·9229	+10·6°	1·4933

To identify the terpenes the first fraction was first agitated with a 50 per cent. aqueous solution of resorcinol until all absorbable constituents were removed.

The odour of terpineol was distinctly marked in the oil of the second fraction, and in order to identify this alcohol the phenylurethane was prepared, this melted at 111° C. Another portion was shaken with a well cooled mixture of equal parts of sulphuric acid and water in small quantities at a time. The unabsorbed oil was removed and the acid solution diluted with 4 volumes of water and stood on one side. Next day an abundance of crystals had formed which were purified and shown to be terpin-hydrate.

In order to separate the terpineol in a fairly pure condition another 100 c.c. of the crude oil were distilled, and the portion boiling above 190° subjected to distillation under reduced pressure; 12 c.c. were thus obtained boiling between 108–115° at 20 mm. the bath at 155–160°. This fraction had rotation a_D +14·8°, and specific gravity 0·932; while the odour was distinctly that of terpineol.

2. Melaleuca Deanei, F.v.M.

Botany.

(a) *Systematic.*—This species was described by Mueller in Proc. Linn. Soc. N.S.W., 1886, p. 1107, and no additional

data have come to light concerning it since that time showing that it is a rare species. The spikes of white downy buds and pale flowers make it an attractive shrub and one worthy of cultivation.

Mueller in his description *(loc. cit.)* states that the leaves are three nerved," but in this feature of venation just a slight point appears to have escaped his observation, viz:—that in some cases the leaves are six or more veined.

(b) *Histology.*—A section of the leaf shows a particular uniformity of anatomical structure. The palisade parenchyma forms a band of a single row around the leaf below a rather narrow epidermis. The vascular bundles are surrounded by xylemic or woody fibres, bounded on the main bundles by supporting tissue, between them and the dorsal and ventral epidermis of the leaf. The mesophyll or spongy parenchyma is composed of thin walled cells, irregularly hexagonal as seen in the section.

A dark deposit characterises some of the sections, this substance being found in the lumen of the woody fibres surrounding the bundles, but occurring more particularly in the mesophyll cells bordering the parenchymatous palisade layers. This substance is evidently not restricted or deposited in any special leaf tissue of the species investigated in this series of papers, viz:—*M. thymifolia*, *M. linariifolia*, *M. nodosa*, *M. uncinata*, *M. bracteata*, *M. trichostachys*, and *M. genistifolia.* It has not, however, been found in *M. gibbosa*, nor *M. pauciflora*, and it was not till after reading the first two papers that it was considered as a manganese compound. A summary of its occurrence in the respective species may not be out of place here. Under *M. uncinata* will be found one of the finest series of microphotographs showing this substance, being very conspicuous in the epidermal cells, spongy parenchyma, and is in such abundance in the cells surrounding

the bundle as to form a dark or black ring around it, (Vol. XLI, pl. xix to xxv). In *M. trichostachys* it is shown, (Vol. XLIV, pl. xlii, xliii), scattered throughout the spongy parenchyma and no where else, whilst in *M. bracteata*, the same paper, it is depicted in the epidermal cells and the centre of the spongy parenchyma, and in the same tissue are seen deposits of it in *M. genistifolia*, and where also only a few indications of it are found in *M. nodosa*.

Crystals of calcium oxalate are fairly plentiful, the first recorded in a Melaleuca leaf. Oil glands are numerous and irregularly scattered throughout the leaf tissues. They vary in size, being larger towards the midrib where their diameter in some cases almost equals the width of the leaf. Towards and around the edge their size is much smaller.

Geographical Distribution.

The original locality is given as Lane Cove, Port Jackson, H. Deane, but Camfield (Proc. Linn. Soc., N.S.W., 1901), records it between Arncliffe and National Park. Mr. F. W. Williams obtained the material from which the chemical results were obtained at Cook's River. It is thus seen to be a rare species, and with the encroachment of the city will probably in the near future be exterminated.

Chemistry of Essential Oil.

The material for this investigation was collected at Cook's River, near Canterbury, New South Wales, in the month of March. It was to the courtesy of Mr. F. W. Williams that we were able to obtain it from this locality, and he kindly assisted the collector of the Technological Museum to procure the leaves for distillation.

Two separate collections were made, one from the young growth, or "suckers," which had sprung from the trees felled about 18 months previously; the other consisting of mature leaves and terminal branchlets from old trees.

The oil glands were pronounced and numerous in the leaves of the younger material, but sparsely distributed in those of the old trees, and it was to this peculiarity that great variations in the yields of oil were experienced. This variation in oil content in the leaves of the younger growth and in those from old trees is not restricted to the of Melaleucas, and we had previously found this peculiarity to obtain with certain species of Eucalyptus, particularly *E. rubida.*

The yield of oil from 72 lbs. of leaves and terminal branchlets from old trees was less than half a cubic centimetre of a dark coloured oil, and it was even necessary to remove it from the distillate by agitating with petroleum ether. The yield from the young material was equal to 0·7 per cent. of a reddish-brown oil with a pronounced terpene odour. It was found to consist very largely of dextro-rotatory pinene, together with a little cineol and a high-boiling alcohol, most probably terpineol judging from the odour.

The crude oil from the young material had the following constants:—

Specific gravity at 15° C. = 0·8888.
Rotation a_D + 22·7°
Refractive index at 22° = 1·4646.

It required 7 volumes 80 per cent. alcohol to form a clear solution. The saponification number for the esters was 5·7, equal to 2 per cent. of terpinyl-acetate. After boiling with acetic anhydride and anhydrous sodium acetate in the usual manner the saponification number was 18·6, indicating about 4 per cent. of free terpineol, if the alcoholic constituent is considered to consist wholly of that substance.

On rectification under atmospheric pressure no less than 33 per cent. distilled between 155 and 158° (uncor.) and 60 per cent. between 158 and 185°.

These two fractions gave the following constants:-

	Sp. gr. at 15°.	Rotation a_D	Ref. index at 16°
First fraction	0·8708	+31·2°	1·4660
Second ,,	0·8830	+21·6°	1·4658

The cineol was determined in the second fraction by the resorcinol method, giving a result equal to 19·5 per cent. of the crude oil, but a phosphoric acid determination only gave a result equal to 15 per cent. cineol in the crude oil. It is thus evident other bodies in addition to the cineol were absorbed by the resorcinol. The alcohol was probably terpineol and was in the dextrorotatory form.

That the greater portion of the oil consisted principally of dextrorotatory pinene was demonstrated in the following manner:—The rectified oil was agitated for some considerable time with a 50 per cent. cold aqueous solution of resorcinol until absorbable bodies were removed. The remaining oil had specific gravity at 15° = 0·8640; rotation a_D + 33·6°; refractive index at 15° = 1·4674, and gave a nitrosochloride melting at 104°.

Although these results are interesting as demonstrating great diversity in the essential oils of the Melaleucas, yet, it is apparent that *Melaleuca Deanei* can have no economic value as an oil producing plant, the chief constituent being pinene, and oxygenated bodies are only present in very small amount.



R.T.B., del.

MELALEUCA DEANEI, F.v.M.

THE ESSENTIAL OIL OF BACKHOUSIA MYRTIFOLIA, PART I.

By A. R. PENFOLD, F.C.S.

Economic Chemist, Technological Museum, Sydney.

[*Read before the Royal Society of N. S. Wales, August 2, 1922.*]

THE botany of this small or medium size tree was first described in "Botanical Magazine," t. 4133, by its authors Hooker and Harvey.[1] It is the grey or "scrub" Myrtle, usually a small tree with myrtle-like leaves and pleasing white flowers found growing in most gullies containing running water in the coast and coast mountain districts of this State, extending to Queensland, being particularly plentiful in the southern district of New South Wales. Although specimens of its essential oil have been in the Technological Museum since 1896, the oil had not previously been examined until Mr. T. H. Brown of Currowan, viâ Nelligen of this State enquired as to its economic value when forwarding a small sample early in 1921. It was then that the writer undertook its investigation.

The Essential Oil.

The oil obtained by steam distillation from the leaves and terminal branchlets is heavier than water, of a brownish yellow colour and pleasing odour. The material from which the oils referred to in this paper were obtained, was procured from Currowan of the southern district of New South Wales, and from Lane Cove, a suburb a few miles on the northern side of Sydney. Altogether 532 lbs weight of leaves and terminal branchlets, cut as for commercial distillation, were distilled, and gave an average percentage

[1] Bentham's Flora Australiensis, Vol. III, page 269.

yield of oil of 0·42%, varying apparently with the time of year, being greatest in the Spring.

The principal constituent has been found to be elemicin—a somewhat rarely occurring phenol ether—present to the extent of 75 – 80%, the remainder being pinene, a paraffin, sesquiterpene, unidentified alcoholic and phenolic bodies.

As there is every prospect of the oil becoming an article of commerce in the near future, the results obtained to date are published as a Part I paper, leaving the examination of further supplies of the oil from other districts, together with the investigation of the alcoholic bodies, for a later communication.

Experimental.

The 532 lbs weight of leaves and terminal branchlets yielded on distillation with steam, crude oils, which on examination, gave the chemical and physical characters shown in the table, page 127.

On distillation at 10 mm. the crude oils yielded 11% boiling between 42 – 139° C., and 83% distilling at 139 – 148° C., leaving 6% residue in the flask. For the identification of the principal constituents the fractions from the Currowan oils were used.

Determination of the Terpene.—The portion boiling at 42 – 139° C. at 10 mm. was redistilled, and the distillate coming over below 75° C., equal to about 1% of the oil, and having a refractive index of 1·4645 at 20° C. was collected. It readily yielded a nitrosochloride, which after purification, melted and decomposed at 109° C. It appears, therefore to be α-pinene.

Unidentified Alcohol.—A fraction was obtained on rectification boiling at 95 – 109° C. at 10 mm. possessing the following characters:—Specific gravity $\frac{15}{15}$° C. 0·9018; optical rotation + 7·6°; refractive index, 20° C. 1·4770. The quantity was insufficient for identification.

Date.	Weight of Leaves.	Percentage Yield of Oil.	Specific gravity at $\frac{15°}{15°}$ C.	Optical Rotation. °	Refractive Index 20° C.	Solubility in 70% Alcohol (by weight).	Ester No. Hot Sap. 1½ hours.	Ester No. after acetylation 1½ hrs. Hot.	Remarks
7/7/21	44 lbs.	0·22	1·0432	+1·8	1·5211	1 in 0·8 vols.	. .	...	Material kindly furnished by Mr. T. H. Brown of Currowan
7/7/21	1 oz sample oil	...	1·0573	+1·2	1·5240	1 in 0·5 „	...	...	Ditto
29/9/21	168 lbs.	0·76	1·0450	+1·2	1·5218	1 in 0·6 „	3·63	24·45	leaves from Currowan
21/10/21	244 lbs.	0·30	1·0256	+0·7	1·5234	1 in 0·75 „	4·5	30·14	leaves from Lane Cove
27/5/22	76 lbs.	0·40	1·0396	inactive	1·5216	1 in 0·7 „	3·1	23·95	leaves from Currowan

Determination of Elemicin.—On redistilling the fraction boiling at 139–148° C. at 10 mm. the greater portion came over at 144–147° C. at 10 mm., and upon repeating same the phenol ether was obtained in a fairly pure condition as is evident from the following characters as determined:—Boiling point at 10 mm. 144–147° C.; Specific gravity $\frac{15}{15}$° C. 1·0665; Optically inactive. Refractive index 20° C. 1·5285.

On combustion the following results were obtained:—

(1) 0·1136 gram. gave 0·2894 gram. CO_2 and 0·7790 gram. H_2O. C—69·47%. H—7·8%.

(2) 0·1238 gram. gave 0·3144 gram. CO_2 and 0·8660 gram H_2O. C—69·25%. H—7·77%.

$C_{12}H_{16}O_3$ requires C—69·28%. H—7·69%.

A molecular weight determination by the Landsberger's boiling point method gave a result of 206·4. Theory requires 208. A determination for the presence of methoxy groups by Ziesel's method gave (1) 40·45% OCH_3 and (2) 40·76% OCH_3 indicative of three such groupings.

The identity of this phenol ether was confirmed by the preparation of trimethylgallic and trimethyl*homo*gallic acids by oxidising it with potassium permanganate in alkaline solution:—20 cc. of the elemicin was shaken with 44 grams powdered potassium permanganate, 6 grams potassium hydroxide, 1400 cc. water and 1400 ice. On completion of the reaction, removal of manganese hydroxide and concentration of the liquor, crystals of trimethylgallic acid were obtained in good yield on acidulation with dilute sulphuric acid. On recrystallisation from alcohol they melted at 169–170° C. Titration with semi-normal alkali solution showed it to be monobasic, of molecular weight 211. $C_{10}H_{12}O_5$ requires 212. The filtrate from the foregoing acid was exhausted with ether, from which solvent another acid was obtained, which on re-crystallisation from alcohol melted at 119–120° C. It proved to be trimethyl*homo*gallic

acid as titration with semi-normal alkali solution showed it to have a molecular weight of 226. $C_{11}H_{14}O_5$ requires 226.

Sesquiterpene.—A portion of the oil boiling at 120–138°C. at 10 mm. gave the well known colour reactions for sesquiterpenes usually present in the essential oils of the Myrtaceæ. It was not possible to purify the quantity available.

Determination of Paraffin.—From the residue boiling above 148° C. at 10 mm. a saturated paraffin was obtained of melting point 62 – 63° C.

Phenols.—Unidentified phenolic bodies were present to the extent of 0·24% to 0·5% in the various oils.

In conclusion I have to express my thanks to Mr. F. R. Morrison, Assistant Chemist, for his usual kindly assistance in this investigation.

ACACIA SEEDLINGS, PART VIII.

By R. H. CAMBAGE, F.L.S.

[With Plates II - V and Text Figure.]

[*Read before the Royal Society of N.S. Wales, September 6, 1922.*]

SYNOPSIS:

VITALITY OF SEEDS IN SEA-WATER.
SEQUENCE IN THE DEVELOPMENT OF LEAVES
NUMBER OF PINNÆ ON ONE LEAF.
CLOSING UP OF PHYLLODES AT NIGHT.
FLOWERING SEEDLINGS.
DESCRIPTION OF SEEDLINGS.

Vitality of Seeds in Sea-Water.

A seed of *Acacia melanoxylon* from Jenolan Caves germinated when placed in boiling water and planted after having been immersed in sea-water for five years.

Sequence in the Development of Leaves.

In Part VII, (p. 106), it was mentioned that 99 species of Acacia had been found to commence with one simply pinnate leaf, while 14 had an opposite pair. The following five may be added to the former list, which brings the total to 104:—*A. acinacea* Lindl., *A. Baueri* Benth. (from Wentworth Falls), *A. hastulata* Sm., *A. rhodoxylon* Maiden, *A. sparsiflora* Maiden.

To the fourteen species commonly having an opposite pair of simply pinnate leaves the following three from Western Australia may be added:—*A. extensa* Lindl., *A. scalpelliformis* Meissn., *A. urophylla* Benth., making the total seventeen.

Number of Pinnæ on One Leaf.

In addition to those phyllodineous Acacias already recorded as having more than one pair of pinnæ on one

leaf (Part VII, p. 106), the following may be added:—*A. implexa* and *A. Koa*, which may have up to six pairs.

Closing Up of Phyllodes at Night.

In Part VII (p. 106), reference is made to the closing up of the phyllodes of *A. complanata* at night, and the following further observations are now recorded:—

A. conferta—phyllodes 6 mm. long, terminals 9 mm. apart in forenoon, 6 mm. apart at night. Phyllodes 1 cm. long, terminals 1·3 cm. apart in forenoon, 8 mm. apart at night.

A. elongata—phyllodes 7 cm. long, terminals 4·2 cm. apart in forenoon, 1·3 cm. apart at night. Phyllodes 9 cm. long, terminals 8 cm. apart in forenoon, 2·5 cm. apart at night.

A. floribunda—phyllodes 2 cm. long, terminals 2·3 cm. apart in forenoon, 1 cm. apart at night. Phyllodes 4 cm. long, terminals 4·7 cm. apart in forenoon, 2 cm. apart at night.

A. longifolia—phyllodes 16·5 cm. long, terminals 26·7 cm. apart in forenoon, 17·3 cm. apart at night. In this case the movement of the terminals of each phyllode was 4·7 cm., or about $1\frac{7}{8}$ inches.

Flowering Seedlings.

Several examples have been given of Acacia seedlings having flowered in 6-inch pots, (Part VII, p. 107), and the following are now added:—*A. Baileyana*, *A. conferta*, *A. decurrens* var. *normalis*, *A. discolor*, *A. doratoxylon*, *A. elongata*, *A. homalophylla* (sparsely), *A. longifolia*, *A. neriifolia*, *A. oxycedrus*, *A. pycnantha* (sparsely, in a 9-inch pot), *A. rigens*, *A. trineura*, *A. Westoni* (where sheltered from frost; one plant about to flower was killed by frost).[1]

[1] See Remarks by J. H. Maiden, this Journal, Vol. LIV, 230, (1920).

Description of Seedlings.

PUNGENTES—(Uninerves).

ACACIA TETRAGONOPHYLLA F.v.M. Seeds from Broken Hill (E. C. Andrews). (Plate II, Numbers 1 and 2).

Seeds black, obovate to almost orbicular, 4 to 5 mm. long, 3 mm. broad, 1·5 mm. thick.

Hypocotyl terete, pale to pinkish-brown, 1·7 to 3 cm. long, 1 mm. thick at base, about ·7 mm. at apex.

Cotyledons sessile, auricled, oval to obovate, 7 to 8 mm. long, 4 to 5 mm. broad, upperside green, underside at first very pale yellow, becoming pale green.

Stem terete, brown, glabrous. First internode ·5 mm.; second 1 to 3 mm.; third 1 to 4 mm.; fourth to seventh 2 to 6 mm.

Leaves—No. 1. Simply pinnate, in two cases an opposite pair appeared, petiole 4 to 9 mm., glabrous; leaflets two pairs, obliquely and irregularly oval to oblong, 4 to 7 mm. long, 3 to 4 mm. broad, upperside green, underside paler, midrib and secondary vein fairly distinct; on one leaf each basal leaflet developed small leaflets on the lower margin, two in one case and one in the other; rachis 2 to 4 mm., with terminal seta; stipules reduced to scales.

No. 2. Abruptly bipinnate, petiole 1·4 to 2 cm., slightly dilated vertically, green, glabrous, with terminal seta; leaflets one to two pairs, oblong-acuminate, mucronate, 4 to 5 mm. long, 1 to 2 mm. broad, upperside green, underside paler; rachis 4 to 5 mm., with terminal seta.

No. 3. Sometimes a phyllode, 1·8 to 4·5 cm. long, 1 mm. broad, or it may be abruptly bipinnate, petiole 1·5 to 2 cm. long, 1·5 mm. broad, with distinct midrib, the upper margin nervelike, with terminal seta; leaflets one to two pairs, in one case the pinna was reduced to a single leaflet, while the other pinna had developed as a leaflet with three small



Acacia tetragonophylla (1 and 2); *A. verticillata* (3 – 5); *A. rigens* (6 – 8); *A. juncifolia* (9 – 11); *A. vomeriformis* (12 - 14).

Three-fourths Natural Size.

ones growing from its side; rachis about 3 mm. with terminal seta; stipules reduced to scales.

Nos. 4 to 10. Linear, pungent-pointed, slightly rigid phyllodes, 1·5 to 4·5 cm. long, ·5 to 1·5 mm. broad, with prominent midrib, particularly on the underside, margins nerve-like which together with the prominent midrib give the phyllode a four-angled appearance. The early phyllodes are sometimes flatter and broader than later ones.

This is the seventh seedling described in this series where the No. 3 leaf has been reduced to a phyllode. (See Part VII, pp. 109, 116).

PUNGENTES—(Spicatæ).

ACACIA VERTICILLATA Willd. Seeds from Botanic Gardens, Sydney (J. H. Maiden, Cultivated). (Plate II, Numbers 3 to 5).

Seeds greenish-brown, oblong, 3 to 4 mm. long, 1·5 to 2 mm. broad, 1 mm. thick.

Hypocotyl terete, pale green, 6 mm. to 1·5 cm. long, about 1·7 mm. thick at base, 1 mm. at apex, glabrous except sometimes with a few roots.

Cotyledons sessile, auricled, oblong, apex rounded, 5 mm. long, 2·5 mm. broad, upperside green, underside paler, sometimes remaining till the phyllodes appear.

Stem terete, green, sometimes slightly striate, glabrous. First internode ·5 mm.; second 1 mm.; third 1 to 2 mm.; fourth to seventh 1 to 4 mm.

Leaves—No. 1. Abruptly pinnate, petiole 4 to 6 mm., green, glabrous; leaflets three to four pairs, oblong-acuminate, about 4 mm. long, 2 mm. broad, upperside green, underside paler; rachis 3 to 4 mm., with terminal seta; stipules reduced to scales.

No. 2. Abruptly bipinnate, petiole 5 mm. to 1 cm., glabrous, with terminal seta; leaflets four pairs, oblong-

acuminate, 3 to 4 mm. long, 1 to 2 mm. broad, upperside green; rachis 5 to 7 mm., with terminal seta; stipules reduced to scales.

Nos. 3 and 4. Abruptly bipinnate, petiole 6 mm. to 1 cm., slightly dilated vertically, glabrous; leaflets four to five pairs; rachis 5 to 8 mm.

No. 5. Usually a phyllode, but may be abruptly bipinnate and similar to No. 4.

Nos. 6 to 60. Linear, tapering, rigid, pungent-pointed phyllodes, usually verticillate and arranged in whorls of about 6 to 8, about 4 to 5 mm. long, with a rather prominent central nerve.

CALAMIFORMES—(Plurinerves).

ACACIA RIGENS A. Cunn. Seeds from Wyalong. (Plate II, Numbers 6 to 8).

Seeds brown, oblong-oval to ovate, 3·5 to 4 mm. long, 1·5 mm. broad, 1 mm. thick.

Hypocotyl terete, greenish-brown, 1·3 to 2 cm. long, 1·5 mm. thick at base, about ·7 mm. at apex.

Cotyledons sessile, oblong, apex rounded, 4 to 5 mm. long, 1·7 to 2·3 mm. broad, upperside green, underside brownish-red to red, with one or two raised lines.

Stem terete, greyish-green, pilose to tomentose. First internode ·5 mm.; second to fourth ·5 to 1 mm.; fifth and sixth ·5 to 2 mm.; seventh 1 to 3 mm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 4 mm., green, glabrous; leaflets two to three pairs, oblong-acuminate, 3 to 5 mm. long, 1·5 to 2·5 mm. broad, upperside green, underside pale green to reddish-green; rachis 3 to 5 mm., with terminal seta; stipules reduced to flat scales.

No. 2. Abruptly bipinnate, petiole 7 mm. to 1·2 cm., glabrous, with terminal seta; leaflets three to five pairs,

oblong-acuminate to cuneate, 3 to 4 mm. long, 1 to 2 mm. broad, upperside green, underside pale green sometimes slightly tinged with red; rachis 3 to 5 mm., with terminal seta; stipules reduced to scales.

No. 3. Abruptly bipinnate, petiole 1 to 2·2 cm.; leaflets four to six pairs; rachis 6 mm. to 1 cm.

In one case a No. 3 leaf was strictly tripinnate.[1]

Nos. 4 and 5. Abruptly bipinnate, petiole 7 mm. to 2 cm., slightly dilated, glabrous; leaflets four to seven pairs; rachis 6 mm. to 1·1 cm.

In one case a No. 4 leaf was strictly tripinnate.

Nos. 6 to 8. Abruptly bipinnate, petiole 2·4 to 8·5 cm., that of No. 8 being sometimes dilated to ·7 mm., with a definite central nerve and a smaller parallel one on each side; leaflets three to seven pairs, oblong-acuminate; rachis 4 mm. to 1·1 cm.; all with terminal seta.

Nos. 6 and 7 may be twice pinnate.

Nos. 9 to 12. These may be phyllodes, or abruptly bipinnate, petiole 6·8 to 13·2 cm., becoming terete, sometimes pilose to shortly tomentose; leaflets five to seven pairs; rachis 6 mm. to 1·4 cm.; stipules reduced to small scales.

Nos. 13 to 20. Linear-subulate, slightly rigid, partly terete, nearly straight phyllodes, usually with a short recurved point, from about 4 or 5 up to 13·5 cm. long.

CALAMIFORMES—(Uninerves).

ACACIA JUNCIFOLIA Benth. Seeds from Eidsvold, Queensland, (Dr. F. L. Bancroft per J. H. Maiden). (Plate II, Numbers 9 to 11).

Seeds mottled black, areola distinct, oblong-oval, 3·5 to 4 mm. long, 2 mm. broad, 1 to 1·5 mm. thick.

[1] This Journal, LIV. 147, (1920).

Hypocotyl terete, at first pale green, becoming reddish-brown, 4 mm. to 2 cm. long, 1 mm. thick at base, ·6 to ·8 mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 5 mm. long, 2 – 2·5 mm. broad, upperside at first brownish-green, becoming green, underside brownish-red, glabrous.

Stem reddish to brownish-grey, scaly at base First internode ·5 mm.; second to seventh 1 to 3 mm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 4 mm., slightly channelled above, reddish, glabrous; leaflets two pairs, oblong-acuminate, 5 to 8 mm. long, 2 to 3 mm. broad, venation obscure, upperside green, underside red; rachis 2 to 3 mm., glabrous, with terminal seta; stipules minute.

No. 2. Abruptly bipinnate, (in one case simply pinnate with one pair of leaflets), petiole 7 mm. to 1·2 cm., reddish-brown, glabrous, with terminal seta; leaflets one to two pairs, irregularly pinnate, oblong-acuminate, the terminal pair sometimes obliquely obovate, 3·5 to 6 mm. long, 3 to 4 mm. broad, venation obscure, upperside green, underside red; rachis 3 to 5 mm., sometimes channelled above, glabrous, with terminal seta; stipules minute.

No. 3. Abruptly bipinnate, petiole 1·7 to 3 cm., with sometimes a faint gland on upper margin; leaflets one or two pairs, up to 6 mm. long, 3 mm. broad, often obovate; rachis 4 to 8 mm.

In two cases leaf No. 3 was simply pinnate, with one pair of abnormal leaflets 6 mm. to 1 cm. long, 4 to 5 mm. broad, as though a pinna had fused into a large leaflet. In one instance the large leaflet was divided at the apex, thus showing the terminals of two leaflets, the lower halves of which were fused.

Nos. 4 to 6. Abruptly bipinnate, petiole 2·6 to 6 cm., in some cases slightly channelled above, sometimes with a

minute gland; leaflets three pairs, oblong-acuminate, 3 to 5 mm. long, 1 to 2 mm. broad, upperside green; underside reddish to red; rachis 4 to 8 mm.

Nos. 7 to 12. Usually linear-subulate phyllodes, with a fairly definite nerve on each side, 2 to 10 cm. long, with a straight or recurved point.

In two cases leaf No. 3 appeared as a small phyllode, but each was succeeded by bipinnate leaves.

UNINERVES—(Triangulares).

ACACIA VOMERIFORMIS A. Cunn. Seeds from Mount Victoria. (Plate II, Numbers 12 to 14).

Seeds dull black, oval to oblong-oval, about 4 mm. long, 2·5 mm. broad, 1·5 mm. thick.

Hypocotyl terete, pale to brownish-pink, 5 mm. to 2 cm. long, 1 to 1·3 mm. thick at base, ·8 to 1 mm. at apex.

Cotyledons sessile, auricled, oblong to oblong-oval, 4 to 6 mm. long, 2·5 to 3 mm. broad, upperside dark green, underside brownish-pink to reddish and red, with raised centre line of darker shade.

In one case two stems appeared which were joined as one, with four cotyledons but only one simply pinnate leaf.

Stem terete, brownish-red, pilose to hirsute. First internode ·5 mm.; second ·5 to 1 mm.; third 1 to 2 mm.; fourth to sixth 1 to 4 mm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 3 mm., sometimes channelled above, green, glabrous; leaflets one to two pairs, oblong-acuminate to obovate, mucronate, 3 to 4 mm. long, 1·5 – 2 mm. broad, upperside green, underside paler, midrib distinct; rachis 2 to 3 mm., with terminal seta.

No. 2. Abruptly bipinnate, (in one case simply pinnate with one pair of leaflets), petiole about 5 mm., channelled above, glabrous, with terminal seta; leaflets two pairs,

oblong-acuminate, mucronate, 2–3 mm. long, 1 to 2 mm. broad; rachis 2 to 4 mm., with terminal seta.

Nos. 3 and 4. The latter may be a phyllode, or both may be abruptly bipinnate, petiole 5 to 9 mm., channelled above; leaflets two pairs; rachis 3 to 5 mm.; stipules small, linear.

Nos. 5 to 10. Obliquely-lanceolate to narrowly triangular, rigid, pungent-pointed phyllodes, about 5 to 7 mm. long, 1 to 1·5 mm. broad, with the midrib towards the lower margin, and with a pronounced angle on the upper edge which is channelled below the angle, the channelling becoming gradually less in the succeeding phyllodes.

There appears to be an interesting association between the channelling of the petioles of the leaves and of that of the upper edge of the phyllodes from the base to the angle, as though the channelled portion of the phyllode may represent the petiole of the earlier leaves.[1]

Several seeds of this species produced twin plants.

It was noticed that plants of this species growing at Mount Victoria favoured the small area of Narrabeen Shale formation rather than the more siliceous Hawkesbury Sandstone.

UNINERVES—(Racemosæ).

ACACIA PYCNANTHA Benth. Seeds from Potts' Hill, Sydney, and Melbourne (Cultivated). (Plate III, Numbers 1 to 3).

Seeds black, oblong, 4 to 5 mm. long, 2·5 to 3 mm. broad, 1·5 mm. thick.

Hypocotyl terete, creamy to reddish-brown, 1 to 5 cm. long, 1·5 to 2 mm. thick at base, ·7 to 1 mm. at apex.

[1] See a paper by J. J. Fletcher, M.A., B.Sc., "On the correct Interpretation of the so-called Phyllodes of the Australian Phyllodineous Acacias." Proc. Linn. Soc. N.S.W., XLV, 24, (1920).



Acacia pycnantha (1 - 3); *A. Westoni* (4 - 6).

Half Natural Size.

Cotyledons sessile, slightly auricled, oblong, apex rounded, upperside green, underside from creamy, tipped with reddish-brown, to red, striate, 5 to 6 mm. long, 3 mm. broad, soon becoming revolute and cylindrical.

Stem terete, brown, glabrous. First internode ·5 mm.; second to fourth ·5 to 1 mm.; fifth to eighth 1 to 4 mm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 4 mm., glabrous to faintly pilose, sometimes with marginal gland; leaflets three to five pairs, oblong-acuminate, 5 to 8 mm. long, 1·5 to 3 mm. broad, upperside green, underside paler, margins often red; rachis 4 mm. to 1·2 cm., glabrous, with terminal seta.

No. 2. Abruptly bipinnate, petiole 5 mm. to 1·1 cm., faintly pilose, sometimes with small gland on upper margin, with terminal seta; leaflets three to five pairs, oblong-acuminate to cuneate, 4 to 6 mm. long, 1·5 to 3·5 mm. broad; rachis 4 mm. to 1·2 cm., with terminal seta; stipules reduced to scales.

Nos. 3 and 4. Abruptly bipinnate, petiole 1 to 2 cm., faintly pilose, No. 4 sometimes dilated to 2 mm. broad, often with gland on upper margin near base; leaflets four to eight pairs, sometimes mucronate, margins often red; rachis 9 mm. to 2·8 cm.; stipules small.

No. 4 may have two pairs of pinnæ.

Nos. 5 to 7. Abruptly bipinnate, sometimes with two pairs of pinnæ, petiole 9 mm. to 4·4 cm., 1 to 5 mm. broad in No. 5, 2 to 8 mm. in Nos. 6 and 7, with strong nerve along lower margin, upper edge nerve-like, often faintly pilose, gland near base, with terminal seta; leaflets six to nine pairs, rachis 1·2 to 3·9 cm.

Nos. 8 and 9. Sometimes abruptly bipinnate, similar to No. 7, or they may be phyllodes.

Nos. 10 to 12. Ovate-falcate to lanceolate-falcate phyllodes, up to 8 cm. long and 3·5 cm. broad, prominent midrib towards the lower margin, penninerved, margins nerve-like, with a prominent gland near the base.

The largest phyllode on a plant 6 inches high was $5\frac{3}{4}$ inches long, by $2\frac{3}{4}$ inches wide, and on a plant 13 inches high was $6\frac{1}{2}$ inches long, and $3\frac{1}{4}$ inches wide.

UNINERVES—(Racemosæ).

ACACIA WESTONI Maiden.[1] Seeds from Queanbeyan (J. H. Maiden). (Plate III, Numbers 4 to 6).

Seeds black, oblong to oblong-obovate, about 5 mm. long, 2·5 mm. broad, 1 to 1·2 mm. thick.

Hypocotyl terete, reddish-brown, about 1·7 to 3 cm. long, about 1·5 to 2 mm. thick at base, 1 mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 6 mm. long, 3 mm. broad, upperside brown, underside reddish to red, soon becoming revolute and cylindrical.

Stem terete, reddish-brown, glabrous. First internode ·5 to 1 mm.; second 2 mm. to 1·1 cm.; third to fifth 2 mm. to 1·3 cm.; sixth 4 mm. to 1·6 cm.; seventh 7 mm. to 2·3 cm.; eighth 1 to 3·7 cm.

Leaves—No. 1. Abruptly pinnate (in a few cases an opposite pair appeared), petiole 3 to 5 mm., glabrous, sometimes with a small gland; leaflets three to four pairs, oblong-acuminate, 4 to 6 mm. long, 1 to 2 mm. broad, upperside green, underside paler; rachis 6 to 8 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 8 mm. to 1·6 cm., gland on upper margin, with terminal seta; leaflets three to four pairs, oblong-acuminate, apical pair often cuneate, 3 to 5 mm. long, 1 to 3 mm. broad; rachis 8 mm. to 1·2 cm., with terminal seta.

[1] This Journal Vol. LIV, p. 227, (1920).



Acacia elongata (1 – 3); *A. implexa* (4 – 6).

Three-sevenths Natural Size.

Nos. 3 and 4. Abruptly bipinnate, petiole 1·2 to 1·7 cm., with marginal gland; leaflets four to seven pairs, similar to those of No. 2; rachis 9 mm. to 2·1 cm.; stipules reduced to scales.

One No. 3 leaf was abnormal, having three pairs of leaflets, irregularly pinnate, but although bipinnate there was no terminal seta on the petiole, and above the middle of the petiole were a pair of large leaflets, one being 8 mm. long and 3 mm. broad.

Nos. 5 and 6. Usually abruptly bipinnate, (though No. 6 may sometimes be a phyllode), petiole 1·4 to 5·4 cm. long, from 1 mm. to 1·7 cm. broad, with marginal gland, and with a strong nerve along or near the base, the upper margin nerve-like, the lamina penninerved; leaflets six to nine pairs, rachis 1·5 to 2·7 cm.

In one case leaf No. 6 had two pairs of pinnæ.

Nos. 7 to 10. Lanceolate-falcate phyllodes, narrowed towards the base, up to 7·5 cm. long, 2·5 cm. broad, the midrib a little below the centre, the margins nerve-like, the lamina penninerved, glabrous.

Phyllodes with as many as three glands are not uncommon on plants a few feet high. The largest phyllode on a plant 13 inches high was scarcely 4 inches long, by $1\frac{1}{8}$ inches wide.

PLURINERVES—(Oligoneuræ).

ACACIA ELONGATA Sieb. Seeds from Brookvale near Manly, Pigeon House near Milton, Woodford on the Blue Mountains, all in New South Wales. (Plate IV, Numbers 1 to 3).

Seeds shiny black, often brown when not quite ripe, Brookvale seeds oval to oblong-oval, 3 to 4 mm. long, 2 to 2·5 mm. broad, about 1·3 mm. thick; Pigeon House seeds oblong to oblong-oval, 3·5 to 4 mm. long, 2 to 3 mm. broad,

about 1·5 mm. thick; Woodford seeds oblong to oblong-oval, 4 to 4·7 mm. long, about 2·3 to 2·7 mm. broad, about 1·3 mm. thick.

Hypocotyl terete, pale below soil, reddish to reddish-brown above, 1 to 2·5 cm. long, 1·3 to 2 mm. thick at base, about ·7 or ·8 mm. at apex.

Cotyledons sessile, sagittate, oblong, apex rounded, about 5 mm. long, 2 mm. broad, upperside green, underside greenish-red to reddish and red, with one or two raised lines along centre.

Stem terete, showing striations from decurrent leaf-stalks, green to greenish-brown, glabrous or with a few scattered hairs in the Brookvale and Woodford examples, pilose to pubescent in the Pigeon House specimens. First internode ·5 mm.; second ·5 mm. to 1·6 cm.; third to fifth 1 mm. to 4 cm.; sixth to ninth 3 mm. to 4 cm.; tenth to fourteenth 5 mm. to 3·7 cm.

The shortest internodes are found among the Pigeon House plants, and the longest among the Brookvale and Woodford seedlings.

Leaves—No. 1. Abruptly pinnate, petiole 4 to 7 mm., green, glabrous; leaflets three to five pairs, oblong-acuminate, 6 to 9 mm. long; 2 to 3 mm. broad, the apical pair sometimes cuneate and up to 4 mm. broad; rachis 6 mm. to 1·3 cm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 1 to 2·4 cm., slender, glabrous, or rarely with a few scattered hairs, with terminal seta; leaflets four to five pairs, oblong-acuminate, 3 to 6 mm. long, 1 to 2 mm. broad; rachis 8 mm. to 2·1 cm., with terminal seta; stipules reduced to scales.

Nos. 3 and 4. Abruptly bipinnate, petiole 1·2 to 2·3 cm., sometimes with a faint marginal gland near the base, in some cases slightly dilated and having a prominent midrib,

in the Pigeon House specimens, glabrous or with a few scattered hairs; leaflets five to eight pairs, underside sometimes reddish; rachis 7 mm. to 1·9 cm.

Nos. 5 to 7. Abruptly bipinnate, petiole 7 mm. to 5·5 cm. often slender in the Brookvale and Woodford plants, dilated up to 1 mm. in the Pigeon House specimens and having a prominent midrib on both sides, in a few cases with a faint gland, glabrous to pilose; leaflets seven to twelve pairs; rachis 7 mm. to 3·7 cm.

Nos. 8 to 13. On some of the Pigeon House seedlings these may be linear phyllodes, but on the Brookvale and Woodford plants they may be abruptly bipinnate, petiole 1·3 to 8 cm. long, less than 1 mm. broad, with a prominent midrib in all cases; leaflets seven to fifteen pairs; rachis 7 mm. to 5 cm.

Some of these leaves may be twice pinnate.

Nos. 14 to 23. Often phyllodes, but on Brookvale seedlings may be abruptly bipinnate, in some cases with two pairs of pinnæ, petiole up to 8 cm. long, 1 mm. broad; leaflets up to fourteen pairs; rachis up to 5·6 cm.

Nos. 24 to 30. Linear phyllodes, with a prominent midrib, and a finer parallel vein on each side, glabrous to pilose, up to 10 to 12 cm. long, about 1·7 mm., 1 mm., and ·7 mm. broad in the Pigeon House, Brookvale and Woodford seedlings respectively.

The phyllodes of this species close up towards the stem at night.

PLURINERVES—(Nervosæ).

ACACIA IMPLEXA Benth. Seeds from Jervis Bay, Camden, and Howell, New South Wales. (Plate IV, Numbers 4 to 6).

Seeds shiny black, oblong-oval to oval, 4 to 5 mm. long, 2·5 to 3·5 mm. broad, 1·5 to 2 mm. thick.

Hypocotyl terete, at first creamy, becoming pinkish-green, 1·5 to 3 cm. long, 1 to 2 mm. thick at base, about ·5 to ·8 mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 6 to 7 mm. long, 2·5 to 3·5 mm. broad, upperside green, underside yellowish to pale brown, usually becoming revolute, often with one or two raised lines or protuberances along centre.

Stem terete, slightly striate with decurrent leaf-stalks, brown, glabrous. First internode ·5 to 1 mm.; second to fourth 2 mm. to 1·8 cm.; sixth to eighth 4 mm. to 2 cm.

Leaves—No. 1. Abruptly pinnate, (in one case from Jervis Bay an opposite pair appeared), petiole 3 to 6 mm., green, glabrous; leaflets five to eight pairs, oblong-acuminate, 5 to 9 mm. long, 1·5 to 2·5 mm. broad, basal and apical pairs smaller, midrib distinct, upperside green, underside pale green; rachis 1·1 to 2·2 cm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 5 mm. to 1·3 cm., rarely with faint gland on upper margin, glabrous, with terminal seta; leaflets four to eight pairs, oblong-acuminate, 3 to 7 mm. long, 1 to 2 mm. broad, basal pair smaller; rachis 9 mm. to 1·4 cm., glabrous, with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 7 mm. to 2·2 cm., somtimes with a faint gland, glabrous; leaflets five to fourteen pairs, oblong-acuminate; rachis 1 to 2·5 cm.; stipules reduced to scales.

Nos. 5 to 7. Abruptly bipinnate, sometimes with two pairs of pinnæ, petiole from 1·5 cm. in No. 5, to 7·5 cm. in No. 7, from 1 to 5 mm. broad in some cases, midrib towards lower margin, and one or two finer parallel veins above, and sometimes one below, small gland on upper margin; leaflets nine to seventeen pairs, rachis 1·6 to 4 cm.

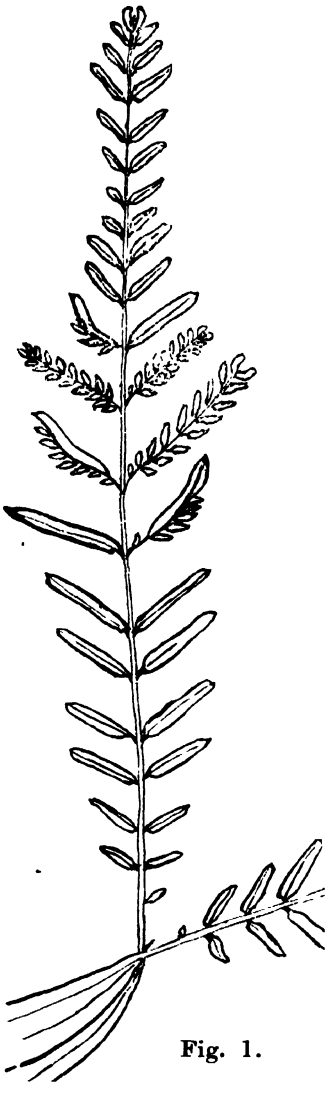


Fig. 1.

A. implexa. × 2.

Nos. 8 to 12. These may be phyllodes, or abruptly bipinnate, very similar to those of No. 7, sometimes with two pairs of pinnæ, petiole 3·6 cm. in No. 8, to 11 cm. in No 12, up to 6 mm. broad, with a few fine longitudinal somewhat indistinct veins in addition to three or four fairly prominent, usually with a small gland; leaflets twelve to nineteen pairs; rachis 2·3 to 4·7 cm.

Nos. 13 and upwards are usually phyllodes, but after the advent of several phyllodes bipinnate leaves may reappear with from one to six pairs of pinnæ, the latter having occurred on a Jervis Bay seedling; some of these pinna have up to twenty-one pairs of leaflets.

One remarkable bipinnate leaf with one pair of pinnæ had one pinna intact with nineteen pairs of leaflets, while the other pinna, with twenty-one pairs of leaflets, had divided leaflets in four cases, viz Nos. 8 to 11. In the case of No. 8 one leaflet was divided into small leaflets along the

lower margin; in No. 9 there were divisions into small leaflets on the lower margin of one leaflet, while the other of the pair was divided on both sides and formed a pinna; in No. 10 each leaflet formed a minute pinna; in No. 11 the the lower margin of one leaflet was divided. (Fig. 1.)

BIPINNATÆ—(Botryocephalæ).

ACACIA ELATA A. Cunn. Seeds from Wentworth Falls, Blue Mountains. (Plate V.)

Seeds black, obovate to nearly orbicular, 5 to 5·5 mm. long, 4·5 to 5 mm. broad, 1·5 to 2 mm. thick.

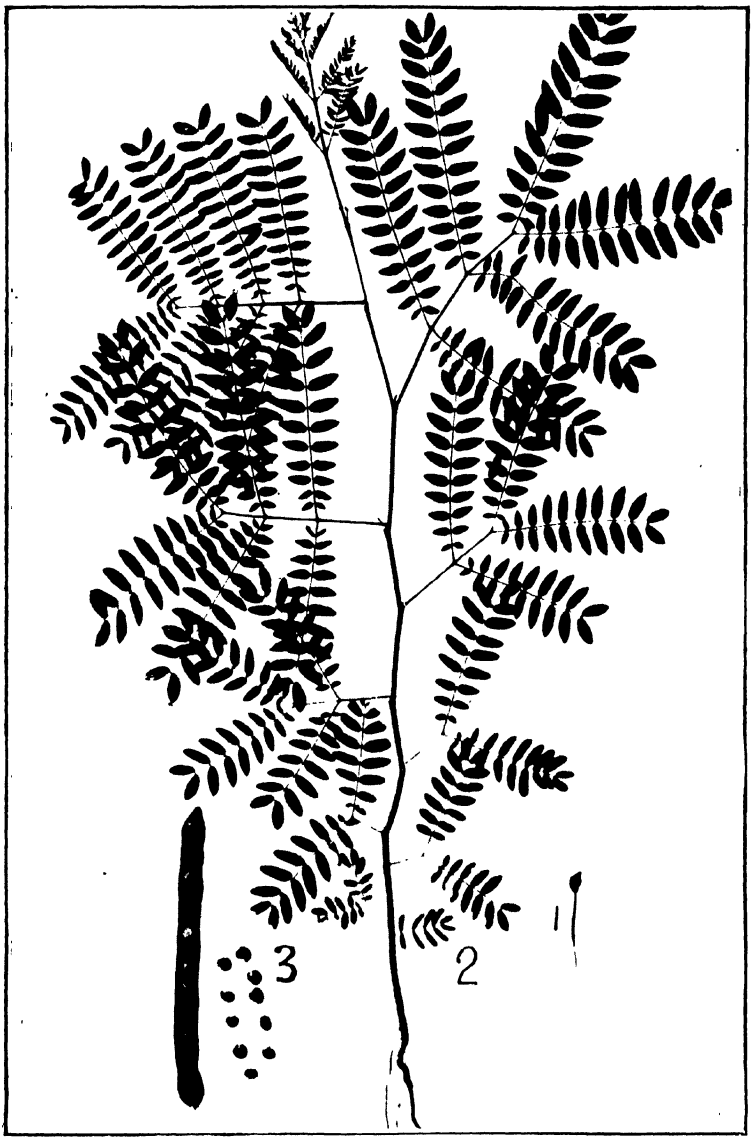
Hypocotyl terete, pale red to red, 1·7 to 4 cm. long, 1·3 to 2·5 mm. thick at base, about 1 mm. at apex.

Cotyledons sessile, slightly sagittate, oblong-oval to obovate, 6 to 6·5 mm. long, 4 to 5 mm. broad, upperside at first red, becoming green, underside red with a few slight longitudinal ridges.

Stem terete, green to brownish-green, glabrous. First internode ·5 to 1 mm.; second and third 2 mm. to 1·2 cm., fourth and fifth 4 mm. to 1·7 cm.; sixth to tenth 5 mm. to 4·5 cm.

Leaves—No. 1. Abruptly pinnate, showing early, petiole 4 to 5 mm., reddish-green, sometimes with small gland, glabrous; leaflets four to six pairs, oblong-acuminate, 6 mm. to 1 cm. long, 2 to 3 mm. broad, upperside brownish-green to green, underside reddish to dark red; rachis 5 mm. to 1·7 cm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 8 mm. to 1·2 cm., often with gland, glabrous, with terminal seta; leaflets four to six pairs, oblong-acuminate, often mucronate, 5 to 7 mm. long, 2 to 3 mm. broad, the basal pair smaller, upperside green, underside reddish; rachis 1·6 to 2·2 cm., with terminal seta.



Acacia elata.

About One-third Natural Size.

Nos. 3 and 4. Abruptly bipinnate, sometimes with two pairs of pinnæ, petiole 1·2 to 2·5 cm., with gland, glabrous; leaflets five to nine pairs, on No. 4 up to 1·1 cm. long, 4 mm. broad, upperside green, underside paler, venation distinct; rachis 2 to 4·8 cm.

Nos. 5 and 6. Abruptly bipinnate, often with two pairs of pinnæ, petiole 2 to 4 cm., with gland towards base and sometimes also at base of terminal pair of pinnæ, glabrous; leaflets eight and nine pairs, up to 1·3 cm. long, 4 mm. broad, basal pair small, upperside dark green, underside pale green; rachis 4 to 5·6 cm.

Nos. 7 to 10. Abruptly bipinnate, with from two to four pairs of pinnæ, petiole 3 to 7·5 cm., with terminal seta; leaflets nine to thirteen pairs, up to 1·5 cm. long, 5 mm. broad; rachis 3·5 to 8 cm.

On a plant 5 feet high, with sometimes seven pairs of pinnæ, the petiole may be 8 cm. long, with one, and in a few cases two glands, the common petiole reaching 27·5 cm. and the pinnæ up to 18 cm. long; leaflets lanceolate-acuminate, underside pale green, minutely silky, sometimes eighteen pairs, up to 3·6 cm. long, 8 mm. broad.

On a mature tree a leaflet may reach 8 cm. ($3\frac{1}{8}$ inches) long, and 1 cm. broad. This species appears to produce the largest leaflet of any in the genus Acacia.

EXPLANATION OF PLATES.

Plate II.

Acacia tetragonophylla F.v.M.

1. Cotyledons, pinnate leaf, bipinnate leaves and phyllodes. Broken Hill, (E. C. Andrews).
2. Pod and seeds.

Acacia verticillata Willd.

3. Cotyledons and pinnate leaf. Botanic Gardens, Sydney.
4. Pinnate leaf, bipinnate leaves and phyllodes.
5. Pod and seeds.

Acacia rigens A. Cunn.

6. Cotyledons. Wyalong, New South Wales.
7. Pinnate leaf, bipinnate leaves and phyllodes.
8. Pod and seeds.

Acacia juncifolia Benth.

9. Cotyledons. Eidsvold, Queensland, (Dr. T. L. Bancroft, per J. H. Maiden).
10. Pinnate leaf, bipinnate leaves and phyllodes.
11. Seeds.

Acacia vomeriformis A. Cunn.

12. Cotyledons. Mount Victoria, New South Wales.
13. Pinnate leaf, bipinnate leaves and phyllodes,
14. Pod and seeds.

PLATE III.

Acacia pycnantha Benth.

1. Cylindrical cotyledons and pinnate leaf. Potts' Hill, near Sydney.
2. Pinnate leaf, bipinnate leaves and phyllodes.
3. Pod and seeds. Bermagui, New South Wales, (W. Dunn per J. H. Maiden).

Acacia Westoni Maiden.

4. Cotyledons and part of pinnate leaf. Queanbeyan, (J. H. Maiden).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Pod and seeds.

PLATE IV.

Acacia elongata Sieb.

1. Cotyledons. Woodford, New South Wales.
2. Pinnate leaf, bipinnate leaves and phyllodes. Pigeon House, Milton.
3. Pod and seeds. Brookvale near Manly.

Acacia implexa Benth.

4. Cotyledons and portion of pinnate leaf. Howell, N. S. Wales.
5. Pinnate leaf, bipinnate leaves and phyllodes. Jervis Bay.
6. Pod and seeds, Jervis Bay.

PLATE V.

Acacia elata A. Cunn.

1. Cotyledons. Wentworth Falls, New South Wales.
2. Pinnate leaf and bipinnate leaves.
3. Pod and seeds.

NOTE ON THE RELATIONSHIP BETWEEN OIL GLANDS AND OIL YIELDS IN THE EUCALYPTS.

By M. B. WELCH, B.Sc.
Technological Museum.

[*Read before the Royal Society of N.S. Wales, September 6, 1922.*]

IN an examination of the leaves of various species of Eucalyptus it is evident that there is a great variation in the size and number of the oil glands, and the object of this investigation was to attempt to find some relationship between the number of glands, allowing for variation in size, and the actual yield of oil attained by steam distillation. No attempt has been made to arrive at any theoretical determination of what the yield should be from such an examination.

In a transverse section of certain species, *e.g.*, those of the Corymbosæ or Bloodwood group, oil glands are not numerous and usually small in size, whilst in *E. terminalis* oil glands are practically absent; on the other hand sections of any of the Mallee leaves *e.g.*, *E. polybractea*, *E. costata*, *E. oleosa*, etc., show an enormous development of the the secretory cavities which apparently form a large proportion of the total leaf structure. Between these two extremes are the majority of species in which oil glands are developed to a greater or less extent.

In attempting to make some comparison between the yield of oil by distillation and the number of glands present, it is obvious that certain factors must be taken into consideration. Thus two species may have in section what appears to be an equal development of oil glands, but on closer examination it is found that one leaf is thicker than

the other and hence the relative number of oil glands per unit area of cross section is much greater in one case than the other. Again the size of the glands varies considerably, not only in the one leaf of a single species but also between species. Thus in *E. corymbosa* the mean diameter of a number of oil glands measured was 0·075 mm., whereas in *E. phytocarpa*, glands were found measuring up to 0·825 mm. in diameter.

Since the volume or theoretical oil bearing capacity of each gland varies as the cube of the radial dimension it is apparent that the size of the gland is especially important in arriving at any comparison of the different species. In some Eucalypts the glands are remarkably regular in size, in others, *e.g.*, *E. hemiphloia*, *E. ligustrina*, etc., great variation was found and in one section may range from 0·25 mm. – 0·075 mm., taking into account medium sections only.

To obtain the relative number of glands present, the average number in a transverse section 5 mm. in length, of the leaves was counted. The mean thickness of the leaves examined was measured and thus it was possible to obtain the number of glands per sq. mm. of cross section. Although naturally the leaves vary in thickness, there is a certain amount of uniformity in mature leaves of any one species. Very often however, a single leaf is not uniform in this respect, even in section at right angles to the mid-rib, *e.g.*, one leaf of *E. robusta* measured 0·480 mm. in thickness near the intramarginal vein, whereas nearer the mid-rib the thickness was 0·375 mm. The thickest leaves are typically those of the Mallees, sometimes averaging in specimens examined 0·60 mm., although *E. coriacea* measured 0·57 mm. and *E. obtusiflora*, a stunted Mallee-like coastal Eucalypt, averaged 0·60 mm.

The figures taken for the yield from the various species are those given in "The Eucalypts and their Essential

Oils," 2nd Edition, Baker and Smith. In practice it is found that the yield of oil varies within limits during the different seasons of the year, and it is to be expected that climatic and ecological conditions would also influence the yield to some extent. It has been found also that the yield of oil is higher in young foliage than when older leaves are used.

A microscopical examination shows that in a number of secretory cavities very little oil is present. Sometimes only a fringe of a dark granular nature is found, whilst in other cases the cavity contains chiefly loose thin walled tissue.

In the accompanying table the average number of glands per length of 5 mm. of transverse section is given in the first column. In the second column, a correction is made for the thickness of the leaf and the mean number of glands per sq. mm. of cross section is shown. In the third column the relative volumes of the glands are given, assuming that the cavity is spherical; this is not always the case, but for the purposes of this comparison is a sufficiently accurate approximation. In the fourth column a figure is given which is the product of the relative capacity of the gland and the number per sq. mm. of section. This figure, which gives a basis for comparison of the possible oil yield of the different species, can be compared with the oil yield which has been obtained by steam distillation, and shown in column 5.

It is seen that although the theoretical figures for certain species with small yields *e.g.*, *E. corymbosa*, *E. corynocalyx*, *E. botryoides*, *E. obtusiflora*, and *E. nigra*, agree fairly well with the actual yields, in the majority of species this is not so, and there is such a wide variation, particularly in *E. aggregata* and *E. rubida*, that it is impossible

from such determinations to predict accurately what the approximate yield of oil will be.

	Number of glands per 5 mm. of cross section	Number of glands per sq. mm. of cross section $=a$	Relative volume oil glands $=b$	$a\ b$	Yield of oil from steam distillation per cent.
1. *E. acaciæformis*...	8·0	7·7	42	323	0·20
2. *E. aggregata* ...	6·5	4·7	100	470	0·04
3. *E. australiana* ...	8·0	6·7	42	281	3·50
4. *E. Baileyana* ...	3·8	2·8	13	35	0·82
5. *E. botryoides* ...	1·3	1·0	9	9	0·11
6. *E. Bridgesiana*	8 3	6·1	22	134	0·67
7. *E. calycogona* ...	10 0	4·3	133	571	1·00
8. *E. coriacea* ..	3·5	1·2	22	26	0·61
9. *E. cornuta* ...	8 0	3·7	13	48	1·2
10 *E. corymbosa* ..	2·0	1·3	6	8	0·06
11. *E. corynocalyx* ..	1·0	0·7	13	9	0·10
12. *E. costata* ...	11·0	3·7	100	370	0·90
13. *E. dives*... ...	10·0	6·3	51	321	2·80
14. *E. eximia* ..	5·0	2·7	22	59	0·46
15. *E. gomiocalyx* ...	9·4	4·5	42	189	1·00
16. *E. hæmastoma* ...	11·2	5·7	13	68	0·44
17. *E. hemiphloia* ...	4·3	2·2	73	161	0·58
18. *E. Lehmanni* ...	6·1	3·3	73	241	0·86
19. *E. ligustrina* ...	3·6	1·4	34	48	0·12
20. *E. maculata* ...	8·9	6·6	9	59	0·23
21. *E. marginata* ...	3·0	1·8	42	76	0·22
22. *E. megacarpa* ..	4·1	2·5	42	105	0·50
23. *E microcorys* ..	7·3	8·1	30	243	0·51
24. *E. Moorei* ...	4·7	1·8	73	137	0·80
25. *E. nigra* ..	2·7	2·4	4	10	0·04
26. *E. obtusiflora* ..	2·2	0·8	9	7	0·00
27. *E piperita* ..	7·1	5·2	34	177	0·80
28. *E phlebophylla*...	10·7	5·3	42	223	1·20
29. *E. Planchoniana*	1·1	0·5	34	17	0·02
30 *E. polybractea* ..	7·9	3·5	133	466	1·50
31. *E. resinifera* ..	3·8	2·0	22	44	0·42
32. *E. robusta* ...	3·5	1·7	42	71	0·16
33. *E. rubida* ...	3·6	2·1	42	88	0·07
34. *E saligna* ..	2·8	2·0	9	18	0·12
35. *E. Smithii* ..	6·2	5·5	51	281	1·80
36. *E. tesselaris* ...	2·1	2·1	9	19	0·16
37 *E. umbra* ...	2·6	1·2	13	16	0·60
38. *E. uncinata* ...	11·1	5·5	51	281	1·80

POISONING OF SHEEP BY SOLANUM CINEREUM.

By SYDNEY DODD, F.R.C.V.S., D.V.Sc.,

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[*Read before the Royal Society of N. S. Wales, September 6, 1922.*]

EARLY during the present year, Mr. Stock Inspector White of Merriwa, forwarded a dried specimen of a plant locally known as "Wild Tomato," to the Chief Inspector of Stock, Sydney, for the purpose of ascertaining what was known concerning it. The plant was suspected by a stock owner in the above district of causing, on more than one occasion, the death of a number of his sheep. A specimen had previously been sent to the Government Botanist, Mr. J. H. Maiden, who identified it as *Solanum cinereum* and stated that it was a native plant, its popular name being "Narrawa Burr." It had spread a good deal during the past few years and to such an extent that several Shires had proclaimed it a noxious weed. He had no knowledge of its being poisonous to stock but suggested that as it belonged to the Solanaceæ, which includes some undoubtedly poisonous species. Veterinary opinion should be sought on the subject.

As a result of correspondence after the experiments to be described had been completed, Mr. White stated that odd plants were to be found in the Merriwa district, but it is only on certain holdings that it is growing in any quantity and here it is becoming somewhat of a pest. Prior to the above incident, he had never heard of the plant being suspected of poisoning stock. Some sheep had at times died mysteriously, but death had usually been attributed

to other plants, *e.g.*, *Euphorbia Drummondii*. Sheep do not feed willingly on the plant, rarely touching it when other food is available; but they will eat it when other food is scarce or dry. On the particular station whence arose the enquiry, there was plenty of dry grass in the paddock where the deaths had occurred, together with a fair amount of *Solanum cinereum*. Only some of the sheep had been eating the fruits of the latter and nibbling at a few of the leaves. Numbers of sheep did not touch either fruits or leaves. The former are generally eaten ripe.

In the case causing the enquiry, there were 1,100 sheep in a particular paddock, and of these 45 died. It was not known what time had elapsed between the first eating of the berries and the commencement of the mortality, but some sheep had been observed eating them two or three weeks before any dead sheep were found. Thirty sheep, however, died, apparently suddenly and quietly, within a few days of each other, from what appeared to the owner to be the result of eating the fruits of the plant later on identified as *Solanum cinereum*. The reasons for this conclusion were that the fruits had been eaten off plants growing in the paddock, and also, when being yarded, the sheep were again observed to do the same thing. The same class of sheep in an adjoining paddock had not touched either leaves or fruits of the plant and no deaths had occurred. The owner also considered that this occurrence presented the same features as were noticed in connection with some previous losses, and which he also thought to be due to the same plant.

In order to experimentally ascertain whether *Solanum cinereum* was toxic or not, Mr. White was requested to forward a consignment for that purpose. About 10 lbs. of the dried mature plant were received, each plant carrying many fruits, but the latter were also quite ripe and

dried up. Although these had a far different appearance to the ripe juicy fruits that the sheep had been feeding on, it was resolved to carry out some feeding experiments with them.

The botanical description of *Solanum cinereum* is given in Bentham's "Flora Australiensis," vol. iv, p. 460.

Feeding Experiments with S. cinereum.

Sheep No. 100, aged 2 years.—Noon 15th, May '22. Administered by mouth 8 ounces of solanum berries (dried) mashed up with water to form a pulp. The animal would not swallow the mixture voluntarily, but was made to take the lot by placing a little at a time in the mouth and waiting until it had been swallowed.

At 2 p.m. when the animal was inspected, it was apparently well. Having been called away for the afternoon, I left instructions that another dose might be given at 4 p.m. if necessary. The animal, however, died at 3·30 p.m. during my absence, $3\frac{1}{2}$ hours after the fruits were administered.

Post mortem examination was made next morning. There was some evidence of salivation and diarrhœa. The liver, kidneys, abomasum and intestines were deeply congested. A number of sub-endocardial hæmorrhages were present. No other lesions were seen.

Owing to the rather unsatisfactory conclusion of this experiment, it was resolved to repeat it, and in order to avoid any suggestion that death may have been hastened by some of the liquid going "the wrong way," it was decided to give the berries whole and free from water.

Sheep No. 101, aged 2 years.—10 a.m., 16th May, '22. Fed with 4 ounces whole, dry berries (96 in number) of *S. cinereum.* The fruits were simply placed in the mouth of the animal, a few at a time. The mouth being lightly held

until the animal had swallowed them. The result was negative; not the slightest sign of inconvenience being seen.

4 p.m., 16th May, '22. Administered the same weight of dry, intact fruits (93 in number) in the same manner as at 10 a.m., making a total weight of 8 ounces within six hours. The result was again negative.

In view of the above negative results and the positive result obtained with Sheep No. 100, although in one case the whole amount of fruits was given at one time, whilst in the other it was given in two lots with an interval of six hours, it was for reasons to be discussed later, decided to give sheep No. 101 the total amount of 8 ounces of berries emulsified in water. The following are the details.

Noon 22nd May, '22. Sheep No. 101 given by the mouth, 8 ounces of *S. cinereum* fruits (266 in number) mashed up with water. The emulsion forming a thick pulp.

2 p.m. 22nd. The animal which normally was very wild, had now become very quiet and easy to handle without assistance. Respirations were stertorous and rather heaving. Temperature 103° F. Slight salivation, mucous membranes intensely congested. Fæces pultaceous.

4 p.m. Temperature 164° F. Pulse 102 and bounding. Respirations 80 and heaving. Profuse salivation. Moderate dilatation of the pupils, mucous membranes cyanotic. A massive and pultaceous motion. Animal able to stand but very weak and easily pushed over. Perspiring freely. Some eructations of gas from the mouth.

7 p.m. Animal dead. There had been some struggling at various intervals and a profuse, fœtid diarrhœa prior to death. Death occurred seven hours after the administration of the berries.

Post mortem examination was made next morning. The sub-cutaneous vessels and peripheral lymphatic glands were congested. About 100 c.c.s of blood stained, turbid liquid in the peritoneal cavity. The spleen showed a number of subcapsular hæmorrhages. The liver was moderately and the kidneys intensely congested. The latter having a number of small hæmorrhages in the cortex. The mucous membrane of the abomasum and intestines was also greatly congested, with a considerable amount of mucus on the surface. The lungs were normal. Pericardium distended with a turbid, blood stained liquid. Numerous sub-endocardial hæmorrhages.

Remarks

On account of the difficulty of administering the dried, intact fruits, they were given in two lots of 4 ounces each, with an interval of about 6 hours. The result as noted, was negative.

Six days later, the animal was given the same total amount of fruits, but this time they were emulsified in water, with the result that death took place in seven hours. The question arises, why should the berries when eaten in the dry state be apparently innocuous, whilst the same amount when mashed up with water causes death in such a short period? The probable explanation is that when the fruits were given whole and dry, they were swallowed in the ordinary way, without preliminary mastication and passed into the rumen. Here they would become mixed with the other contents of that portion of the stomach. When rumination took place, the amount of fruits masticated, re-swallowed and passed on to the true digestive stomach, would not only be non-lethal, but insufficient to cause any visible symptoms of poisoning. On the other hand, when the fruits were mashed up in water, only a little of the mash was found in the rumen post mortem.

Furthermore, all the liquid portion of the emulsion containing the soluble alkaloids, would pass direct into the abomasum etc.; consequently, as a lethal dose had reached that part of the alimentary tract where absorption would take place, death occurred rapidly.

Chemical analysis of the fruits is now being conducted by the Department of Agriculture. The result of this has not yet been made known. The clinical evidence however, appears to indicate that the plant belongs to the Solanine group of the Solanaceæ, rather than the Atropine or Nicotine groups, and that the glucosidal alkaloid solanin is the principal active agent.

Conclusions

The fruits of *Solanum cinereum* contain a poisonous principle, probably Solanin. If the fruits are eaten fresh and in sufficient quantity (at least 8 ounces, and this is not a large amount to ingest at one time), the soluble alkaloid passes directly into the abomasum and will cause death in a few hours. The chief symptoms of poisoning by this plant are, salivation, perspiration, intense congestion of the visible mucous membranes, disordered cardiac and respiratory actions and diarrhœa. In small amounts, however, the fruits do not apparently occasion any pronounced illness. The symptoms shown by the experimental animals, and the post mortem findings, indicate that the principal active toxic agent is Solanin. Dried fruits, even in poisonous amounts do not produce any ill effects unless a relatively large quantity be consumed.

ON THE OCCURRENCE OF L-PHELLANDRENE IN THE OIL OF MELALEUCA ACUMINATA.

By HENRY G. SMITH, F.C.S.

[*Read before the Royal Society of N. S. Wales, October 4, 1922.*]

SHORTLY prior to my retirement from the Technological Museum there was received from Professor A. J. Perkins of the Agricultural Department of South Australia, a sample of the oil of *Melaleuca acuminata* for report, which had been distilled in Kangaroo Island, where this Melaleuca is known as "Lavender Bush."

There is a considerable industry carried on in Kangaroo Island in the distillation of Eucalyptus oil from leaves of *Eucalyptus cneorifolia* and *E. odorata*, and it was suggested that perhaps this Melaleuca might produce an oil of equal value.

As the chief terpene was found to be phellandrene it was thought desirable that permanent record should be made of the fact, particularly as this appears to be the first time that phellandrene has been found in the oils of species belonging to this genus.

In April, 1892, Messrs. Schimmel & Co. received from Messrs. Cumming & Co. of Adelaide, a sample of the oil of this species, and record (Semi-annual report, April) the specific gravity as 0·892, and rotation a_D −15° 2′, also that it contained much cineol; but no attempt appears to have been made to identify the terpenes.

It will be observed how closely these constants agree with those now recorded, which again supports the conclusion of relative constancy of the oil products of individual species grown under natural conditions.

The amount of oil obtained from one 400 gallon square iron tank was 17 pounds; the weight of material distilled was not stated, but was probably about 900 to 1000 pounds, giving a yield of about 1·7 to 2 per cent. The crude oil was almost colourless, very mobile, and contained a considerable amount of cineol. It had specific gravity at 15° = 0·8935; rotation a_D −12·8°; refractive index at 20° = 1·4690; acid number 1·1; saponification number 4·5; saponification number of esterised oil 21·2. Cineol determined by the resorcinol method in the portion boiling below 190°, and calculated for the crude oil, was 43·7 per cent.

On rectifying under atmospheric pressure only a few drops distilled below 165° (uncor.); between 165−170° 30 per cent. distilled; between 170−190° 62 per cent. came over, and between 190−220° 2·5 per cent. distilled. The first two fractions gave the following results:—

	Sp. gr. at 15°	Rot. a_D	Ref. ind. at 20°
First fraction	0·8825	−13·5°	1·4661
Second ,,	0·8922	−13·2°	1·4685

The third fraction was added to the residue and the saponification number determined, this was 15·9, indicating the ester to be high boiling.

Terpenes.—It was found that the cineol phosphate compound could be separated from the terpene portion. The method adopted was to slowly treat the rectified oil in a beaker with phosphoric acid until judged to be in excess. The pasty mixture was then warmed until the greater portion of the cineol phosphate separated, the liquid portion poured off and the beaker containing it placed in ice water until the remaining cineol phosphate crystallised out. The remaining liquid was then well shaken with a 50 per cent. by weight aqueous solution of resorcinol, in order to remove any remaining cineol or alcoholic bodies that might be present; the terpenes were then well washed, dried and filtered.

On rectifying the terpenes as thus prepared practically nothing distilled below 166° (uncor.). Between 166–168° 39 per cent. distilled; between 168–172° 39 per cent. came over, leaving 22 per cent. boiling above 172°. The two fractions gave the following results:—

	Sp. gr. at 15°	Rot. α_D	Ref. ind. at 20°
First fraction	0·8568	−20·8°	1·4735
Second ,,	0·8542	−21·2°	1·4794

Apparently a very small quantity of pinene was present in the first fraction, judging from the boiling point and physical constants; but the reaction for phellandrene was most distinctive. The nitrosite was prepared using sodium nitrite and acetic acid in the usual way, and when purified by dissolving in chloroform and precipitating with methyl alcohol, melted at 105-6°. It was dextrorotatory and 0·1552 gram. in 10 c.c. chloroform rotated the ray 1·0° to the left in a decimetre tube; the specific rotation was thus $[\alpha]_D$ +64·4°.

It is thus evident that the principal terpene in the oil of *Melaleuca acuminata* is lævo-phellandrene, and judging from some of its reactions it is probable that when completely investigated this phellandrene will be found not to be identical in constitution with the l-phellandrene occuring in the oils of species belonging to the "Peppermint group" of Eucalypts. This matter is to receive further investigation.

The ester and free alcohol in the oil of this Melaleuca were but small in amount, as was also the sesquiterpene. The alcohol was high boiling and probably terpineol.

THE ESSENTIAL OILS OF TWO LEPTOSPERMUMS.

By A. R. PENFOLD, F.C.S.

Economic Chemist, Technological Museum, Sydney.

[*Read before the Royal Society of N. S. Wales, October 4, 1922.*]

SOME time ago, Mr. E. Cheel of the National Herbarium, Sydney, kindly directed my attention to the advisability of examining the essential oils about to be detailed. I am much indebted to him for furnishing me with the names of suitable localities and for authentic specimens to enable sufficient material to be procured for oil distillation. My thanks are likewise due to him for his particularly generous action in allowing me to include the original description of a new variety (*L. flavescens* var. *leptophyllum*, Cheel) in order to facilitate the publication of the chemistry of the oils.

LEPTOSPERMUM FLAVESCENS var. MICROPHYLLUM.

This variety has already been described by Bentham, Flora Aust., Vol. iii, p. 105. It is a tall graceful shrub varying from about 4 to 12 feet in height and much resembling *L. flavescens*, Smith. In fact it is the northern form of that species, being common in the northern parts of New South Wales and Queensland. Leaves and terminal branchlets for this investigation were obtained from Fraser Island, Queensland, through the courtesy of the Director of Forests of that State, who also kindly furnished the following information in regard to its habitat:—"this plant reaches its best on dry hard flats adjacent to running water. It does not grow at all on the loose sand on hillsides, and although sometimes found on swampy wet ground it does not appear as healthy as when growing in the firm sand found on dry flats here."

The Essential Oil.

The oils obtained from two consignments of leaves were of a deep yellow colour, quite limpid and possessed a pleasant terpenic odour. The oil differs from that of *L. flavescens*, Smith, described by the writer in this Journal, Vol. LV, (1921) pages 170–180, in the apparent absence of the characteristic minor constituent, citral, the very small amount of phenolic bodies present, and the much lower yield of oil. Cineol, however, was detected and found to be present to the extent of about 3–5%, this being the first record of the occurrence of this constituent in the essential oils of the Leptospermum.

The principal constituents of the oil so far identified are:

(1) d α Pinene.

(2) Sesquiterpenes—probably eudesmene as principal one.

(3) Sesquiterpene alcohol, unidentified.

(4) Cineol 3 to 5%.

Experimental.

Two consignments of leaves and terminal branchlets (the second one being a check for percentage yield and variation due to time of year) kindly furnished by the Director of Forests, Brisbane, from Fraser Island, Queensland, yielded on distillation with steam crude oils, possessing the chemical and physical constants as shown in table:—

Date.	Weight of Leaves.	Percentage Yield.	Specific Gravity 15/15° C.	Optical Rotation.	Refractive Index. 20° C.
12/3/1921	453 lbs.	0·35%	0·8974	+20·6°	1·4821
11/8/1922	96 lbs.	0·20%	0·9245	+15·8°	1·4960

Solubility in 80% alcohol (by weight).	Ester Number Hot 1½ hours.	Ester Number Hot after acetylation.
insoluble in 10 vols.	6·8	37·33
ditto	8·54	63·59

On distillation at 10 mm. the first lot yielded 58% boiling at 45–56° C.; 6% between 60–72° C.; 5% at 72–118° C. and 25% between 118–135° C., whereas the second con-

signment gave 20% boiling below 60° C.; 10% between 60–120° C.; 30% at 123–133° C. and 29% at 140–157° C.

Determination of the Terpene.—The fractions boiling below 60° C. at 10 mm. on redistillation at 765 mm. were found to consist almost entirely of d α pinene with a small amount of cineol. On removal of the latter by means of resorcin solution, the greater portion boiled at 155–157° C. and had a specific gravity at $\frac{15°}{15}$ C. 0·8637, optical rotation +32·65°, and refractive index 20° C. 1·4665. On mixing with an equal volume of *l* α pinene $(a)_{D\ 20°}$ −50·18° a copious yield of nitrosochloride was obtained, which on purification melted and decomposed at 109° C.

Its identity with d α pinene was confirmed by the preparation of pinonic acid:—116 ccs. were shaken with two litres of 12% potassium permanganate solution and one kilo of ice for several hours, when the reaction was completed. After removal of manganese sludge the liquid was steam distilled to remove unchanged terpene and evaporated to a small bulk. It was then acidulated with dilute sulphuric acid and the acid extracted with chloroform. On removal of the solvent, the liquid acid was distilled under reduced pressure. It boiled at 188–192° C. at 15–16 mm., and became semi-solid on standing overnight at room temperature. The crystals were separated and purified. They melted at 68° C. and gave a semicarbazone melting at 207° C. 0·4064 gram in 10 cc. $CHCl_3$ gave $(a)_{D\ 20°\ C.}$ + 92·27°.

The terpene is therefore, d α pinene.

Determination of Cineol.—This constituent was recovered from the resorcin solution (see above) by steam distillation, when it was obtained in very small amount. Its identity was established by its behaviour with phosphoric acid and the preparation of the iodol derivative which melted at 111–112° C.

Determination of Sesquiterpenes and Sesquiterpene Alcohol.—These were worked up from the fractions of oil boiling above 120° C. at 10 mm. That from the first lot boiling at 118 – 135° C. on repeated distillation over sodium at 10 mm. finally gave the following fractions in the proportion of one of the former to 2·5 of the latter.

Boiling point at 10 mm.	121 – 128° C.	129 – 132° C.
Specific gravity at $\frac{15}{15}$° C.	0·9195	0·9202
Optical rotation	inactive	+ 2·8°
Refractive index 20° C.	1 4996	1·5040

The second lot of oil gave only one sesquiterpene fraction boiling at 129 – 132° C. at 10 mm., had:—

Specific gravity at $\frac{15}{15}$° C.	0·923
Optical rotation	– 1·75°
Refractive index at 20° C.	1·5041

The higher boiling portion (140 – 157° C. at 10 mm.) of

Specific gravity at $\frac{15}{15}$° C.	0·9659
Optical rotation	+ 17·92°
Refractive index at 20° C.	1·5090

consisted largely of a sesquiterpene alcohol. Although not identified, it closely resembled the liquid form of eudesmol.

The sesquiterpene fractions beyond giving the usual colour reactions with bromine vapour and acetic anhydride did not form any solid derivative. As insufficient oil was available to ensure undoubted purity, the writer thinks it advisable to consider the principal sesquiterpene as identical with eudesmene. *Phenols*—The amount of phenols present was very small, not exceeding 0·25%.

Acknowledgment is due to Mr. E. H. F. Swain, Director of Forests, Brisbane, and Mr. Epps of Fraser Island, for their kindly assistance and interest in furnishing the supplies of leaves for the investigation.

LEPTOSPERMUM FLAVESCENS, Sm., var. LEPTOPHYLLUM, Cheel.

L. flavescentes similis sed foliis, leptophyllous-augustatis.

The general habit as well as the flowers and fruits of this variety are very similar to the typical species in the neighbourhood of Sydney, but the leaves are thinner in texture and narrower and longer than the typical form.

Specimens in the National Herbarium are as follows: Copmanhurst, E. Cheel and J. L. Boorman; Ponds Creek, near Tingha, R. H. Cambage (No. 987); Narrabri, G. Burrow; Pillaga Scrub, E. H. F. Swain; Western Australia, W. de Beuzeville and Dr. J. B. Cleland; Cuttabri, J. L. Boorman and H. I. Jensen. In Queensland it has been collected from the following localities: Noondah Creek, near Brisbane C. T. White; Chermside, C. T. White and Francis; Chinchilla, R. C. Beasley; Noosa, R. L. Higgins; Mount Perry, J. Keys (No. 583); Rockhampton, J. H. Maiden.

My thanks are due to Mr. J. H. Maiden, I.S.O., F.R.S., Director of the Botanic Gardens, Sydney, for his kind permission to use the records of material contained in the National Herbarium.

To the above original description kindly furnished by Mr. E. Cheel, the writer can only add, that through the courtesy of Mr. Gordon Burrow of Narrabri, he was afforded an opportunity of inspecting this plant in the field. It was growing in the hard sand on flats adjacent to running water, a habitat identical with that of *L. flavescens* var. *microphyllum*.

The Essential Oil.

220 lbs. of leaves and terminal branchlets obtained from the State Forest at Narrabri, New South Wales, in August 1921, yielded on distillation with steam 1·13% of a pale yellow coloured mobile oil of pleasant odour. This comparatively large yield readily distinguishes it from that of the variety *microphyllum*.

It possessed the following characters:—

Specific gravity at 15° C., 0·8990.

Optical rotation, +14·12°.

Refractive index 20°C., 1·4810.

Solubility in 80% alcohol (by weight), sol. in 7 vols.

Ester Number Hot 1½ hours, 2·04.

Ester Number Hot, 1½ hours after acetylation, 63·24.

On distillation at 10 mm. the crude oil yielded 62% boiling at 50 – 70° C.; 13% at 70 – 110° C.; and 22% between 110 – 140° C. These fractions possessed the following constants:—

Specific gravity at 15° C.	0·8793,	0·9119 and	0·9335 respect.
Optical rotation	+ 14·9°	+ 9·6 ,,	+15·2° ,,
Refractive index 20° C.	1·4695	1·4782 ,,	1·5011 ,,

Determination of Terpenes.—Repeated fractionation of the oil boiling at 50 – 70° C., and removal of cineol by means of resorcin solution, resolved it into about equal volumes of the following fractions:—

Boiling point.	155 – 160° C.	and 160 – 166° C.
Specific gravity at $\frac{15}{15}$° C.	0·8642	0·8645
Optical rotation	+17·5°	+11·2°
Refractive index at 20° C.	1·4716	1·4755

The first readily gave a good yield of nitrosochloride which melted and decomposed at 109° C. The second portion on oxidation with alkaline permanganate solution by the method described in "Parry's Essential Oils," second volume, page 37, yielded crystals of sodium nopinate in quantity. These on decomposition with dilute sulphuric acid yielded the free acid which on recrystallisation from benzene melted at 127° C.

The terpenes are therefore α and β pinene.

Determination of Cineol.—On subjecting the resorcin solution washings from the terpenes to steam distillation a small amount of impure cineol was obtained. Its be-

haviour with phosphoric acid and the preparation of the iodol derivative melting at 111 – 112° C. confirmed its presence. Quantitative estimations made, using the fraction of oil boiling below 190° C. at 760 mm., showed the presence of about 8% of this constituent in the crude oil using the phosphoric acid method, and about 14% by the resorcin method.

Determination of Terpineol.—In working up about 600 c.c. of the crude oil for constituents distilling above 200° C. a fraction of 15 c.c. boiling at 99 – 101° C. at 10 mm. was obtained having the following constants:—Specific gravity $\frac{15}{15}$° C. 0·9296; optical rotation +9°, and refractive index 20° C. 1·4838. On shaking with 5% sulphuric acid crystals of terpene hydrate were obtained melting at 117 – 118° C.; the resulting terpin then melting at 104° C. A nitrosochloride was also prepared which on recrystallisation from ethyl acetate melted at 112 – 113° C. The alcohol is therefore α terpineol.

Determination of Sesquiterpene and Sesquiterpene Alcohol.—Repeated fractionation of the high boiling portions at 10 mm. finally yielded the following distillates, which in the case of the sesquiterpene were carried out over metallic sodium:—

Boiling point at 10 mm.	129 – 132° C.	and 132 – 135° C.
Specific gravity at $\frac{15}{15}$° C.	0·9239	0·9284
Optical rotation	+14·45	+19·75
Refractive index 20° C.	1·5037	1·5057

No solid derivatives could be obtained from either of these fractions, but both gave the usual colour reactions for sesquiterpenes met with in this type of oil. It will no doubt be found to be identical with eudesmene.

The portion boiling above 140° C. at 10 mm. having a specific gravity at $\frac{15}{15}$° C. of 0·9606, optical rotation +12·4,

and refractive index at 20° C. of 1·5100 contained considerable sesquiterpene alcohol.

The principal constituents of this oil, so far determined, are:—α and β pinene; cineol, about 8/10%; α terpineol; sesquiterpene and sesquiterpene alcohol.

This is the first recorded occurrence of terpineol in the essential oils of the Leptospermum. Although its presence had previously been suspected, the writer was unable to identify it.

My thanks are due to the Forestry Commission of New South Wales and Mr. Gordon Burrow, District Forester at Narrabri, for kindly furnishing the excellent supply of material for distillation; to the latter gentleman also for many kindnesses shown the writer when on an official visit to Narrabri in September, 1921.

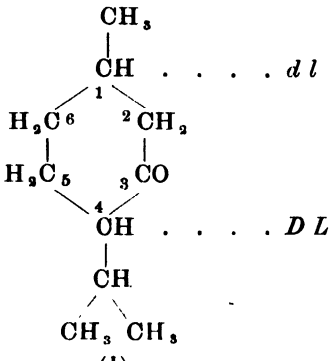
Whilst the essential oils described herein are practically of no economic value, the results of the investigation are certainly of scientific interest. They have afforded confirmation of the botanical differentiation in showing the differences between *L. flavescens*, Smith, and its variety *microphyllum* on the one hand, and the latter with its closely related form, *L. flavescens*, Sm. var. *leptophyllum*, Cheel, on the other.

THE STEREOISOMERIC FORMS OF MENTHONE.

By REGINALD SLATER HUGHESDON,[1] HENRY GEORGE SMITH, and JOHN READ.

[*Read before the Royal Society of N. S. Wales, November 1, 1922.*]

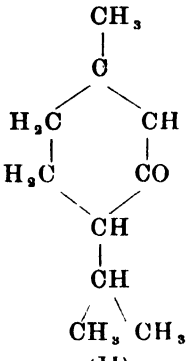
FROM a stereochemical point of view the molecular constitution of menthone (*p*-menthan-3-one) is of particular interest, since it presents one of the best known examples of a cyclic structure containing two dissimilar asymmetric carbon atoms (Nos. 1 and 4, Formula I):



(I)

Menthone.

(*p*-menthan-3-one)



(II)

Piperitone.

(Δ^1-*p*-menthen-3-one)

The presence in the molecule of two such atoms should permit of the existence of four optically active forms of menthone. The two enantiomorphic spacial environments, and the corresponding right- and left-handed optical effects of carbon atom No. 1 may conveniently be indicated by the symbols *d* and *l*, respectively, whilst the symbols *D* and *L* may be used similarly for carbon atom No. 4. The four

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optically active menthones are then represented by the symbols *Dd*, *Ll*; *Ld*, and *Dl*. The first two of these optical isomers are wholly uncompensated substances, possessing the maximum rotatory power for the structure concerned, whilst the last two may be regarded as partially internally compensated compounds of lower rotatory power. Furthermore, these four optically active forms may combine in pairs to give rise to two fully racemic menthones, represented by the symbols *Dd*,*Ll* and *Ld*,*Dl*.

Menthone occurs in essential oils in dextro- and lævogyrate forms which are generally supposed to correspond with each other and with the *l*-menthone obtained from natural *l*-menthol by oxidation with chromic acid (Beckmann, Annalen, 1889, *250*, 325). Since, however, the menthones do not combine with sodium bisulphite, and since, further, they are liable to undergo "inversion" when regenerated from derivatives, such as the oximes and semicarbazones, the stereochemical characterisation of natural or synthetic forms of this ketone is a problem of considerable difficulty.

l-Menthone obtained by the oxidation of natural *l*-menthol has a maximum optical rotatory power of $[\alpha]_D$ −28·46°, and by treatment with cold 90 per cent. sulphuric acid a maximum inversion value of $[\alpha]_D$ +28·14° is exhibited (Beckmann, *loc. cit.*, 335; Ber., 1909, *42*, 846). The inversion, which is conditioned by alkali as well as by acid, has been attributed to enolisation and consequent loss of asymmetry of carbon atom No. 4: it appears, therefore, that *l*-menthone should be assigned the configuration *Ld* (compare Barrowcliff, Trans. Chem. Soc., 1907, *91*, 875; also Gardner, Perkin and Watson, Trans. Chem. Soc., 1910, *97*, 1756). *d*-Menthone would thus be *Dl*, and the configurations *Dd* and *Ll* would correspond, respectively, with the dextro- and lævo-rotatory forms of *iso*menthone, that is, with *d*- and *l*-*iso*menthone.

From the inversion results, if the above explanation is correct, it follows that the optical rotatory effect of carbon atom No. 1 is less than that of No. 4, and hence the sense of the optical rotation is determined by the spacial distribution of the groups about No. 4. In other words, the optical effects of the two asymmetric carbon atoms are opposed in the active menthones and conjoined in the active *iso*menthones.

Inverted *l*-menthone appears to consist of a mixture of *l*-menthone and *d-iso*menthone. By oxidising *l-iso*menthol Beckmann (J. pr. Chem., 1897, *55*, 18) obtained *iso*menthones having values of $[\alpha]_D$ from $+30^\circ$ to $+35^\circ$, whilst a preparation made by an indirect method from *l*-menthone oxime had the remarkably high value, $[\alpha]_D$ $+93{\cdot}2^\circ$ (Ber., 1909, *42*, 846). Furthermore, Barrowcliff *(loc. cit.)*, by means of the reaction with semicarbazide, isolated an *iso*menthone having $[\alpha]_D$ $+47{\cdot}1^\circ$ from the essential oil of American pennyroyal (*Hedeoma pulegioides*), and estimated the value for the optically pure ketone at about $[\alpha]_D$ $+97^\circ$.

It has already been shown (Smith and Penfold, this Journal, 1920, *54*, 40) that the eucalyptus ketone, piperitone, can be hydrogenated in the presence of finely divided nickel at $175-180^\circ$, without the keto-group undergoing alteration. In the course of a recent series of investigations, as yet unpublished, in which by the application of a method independent of oxidative breakdown we have been able to confirm the structural identity of *dl*-piperitone with $\triangle^1$-*p*-menthen-3-one (Formula II), it became necessary to prepare comparatively large quantities of menthone from *dl*-piperitone. Among the successful methods employed was that of direct hydrogenation by the catalytic method of Paal, in the presence of colloidal palladium. The menthone obtained in this way was optically inactive and consisted mainly, or perhaps wholly, of *iso*menthone. It

yielded a sparingly soluble semicarbazone melting, after careful purification, at 219 – 220°, and was apparently identical with the inactive menthone obtained by Wallach (*a*) from $\triangle^1$-*p*-menthen-3-one, synthesised in turn from 1,3,4-trioxyterpane, and (*b*) from 1,4-methylhexanone (Annalen, 1908, *362*, 272). The semicarbazone described by Wallach melted in each instance at 210 – 212°, but the lower value is readily accounted for by the presence of a more fusible isomeric semicarbazone (compare Wallach, "Terpene und Campher," 1914, 377), which we have now isolated in a state of purity. The same optically inactive *iso*menthone was evidently also obtained by Pickard and Littlebury (Trans. Chem. Soc., 1912, *101*, 109), by the catalytic hydrogenation of thymol, the melting point of the semicarbazone in this instance being 217°.

Hitherto, no definite correlation appears to have been established between inactive *iso*menthone and the various preparations of *d-iso*menthone which have been described from time to time. It was therefore of considerable interest to find that lævo-rotatory piperitone, extracted from the essential oil of *Eucalyptus dives*, yielded a highly dextro-rotatory *iso*menthone when hydrogenated in the presence of colloidal palladium. As an example, a specimen of *l*-piperitone having $\alpha_D^{20} - 48{\cdot}05°$ yielded a menthone which after purification had $\alpha_D^{20} + 58{\cdot}33°$. This result indicates that optically active piperitone, when hydrogenated under appropriate conditions, yields an optically active *iso*menthone having a reversed and enhanced rotatory power. Through the courtesy of Dr. Simonsen, of the Forest Research Institute, Dehra Dun, India, we were able to submit a specimen of *d*-piperitone, obtained from the essential oil of the Himalayan grass, *Andropogon Jwar-*

ancusa, to similar treatment (compare Trans. Chem. Soc., 1921, *119*, 1644; 1922, *121*, 582). A specimen of the dextrogyrate piperitone, having $\alpha_D^{17}+47{\cdot}46^\circ$, was thereby converted into a lævo-gyrate *iso*menthone, having $\alpha_D^{19}-57{\cdot}40^\circ$, thus confirming the previous result.

The work of Pope and Read (Trans. Chem. Soc., 1913, *103*, 1515) on partially racemic compounds of the non-electrolytic type suggested the possibility of the optically active *iso*menthones now described belonging to this type. In such an event these isomers would be represented by the symbols *Dd*,*Dl* and *Ld*,*Ll* respectively, and the catalytic hydrogenation of the optically active forms of piperitone would not be an asymmetric synthesis. Correspondingly, a second pair of partially racemic menthones can be imagined, in which carbon atom No. 4 fails to exert its potential activity; these would be represented by the symbols *Dd*,*Ld* and *Dl*,*Ll* respectively. All such isomers might perhaps be classified most simply as partially racemic *iso*menthones: 1-racemic in the first instance, and 4-racemic in the second.

On the whole it appears unlikely that the catalytic hydrogenation of the optically active forms of piperitone should occur otherwise than as an asymmetric, or, at least, a partially asymmetric synthesis. Further investigations, including inversion experiments, are being undertaken in order to test this point and other closely associated ideas. In addition, attention is being devoted to the characteristics of the optically active and inactive menthols which it has been found possible to derive in various ways from piperitone. It may be stated that preliminary work has resulted in the isolation of an inactive menthol, which in view of its melting point (39 – 41°) is probably to be classified as an *iso*menthol, derived from *iso*menthone (compare Pickard and Littlebury, *loc. cit.*).

In concluding this preliminary paper it is convenient to summarise the various stereoisomeric forms of menthone which appear on theoretical grounds to be capable of existing:—

1. *Dd* } Wholly uncompensated compounds: *d*- and *l*-*iso*-
2. *Ll* } menthones, respectively.

3. *Dl* } Partially internally compensated compounds: *d*-
4. *Ld* } and *l*-menthones, respectively.

5. *Dd*,*Dl* } Partially racemic compounds: 1-racemic *iso*-
6. *Ld*,*Ll* } menthones.

7. *Dd*,*Ld* } Partially racemic compounds: 4-racemic *iso*-
8. *Dl*,*Ll* } menthones.

9. *Dd*,*Ll* } Wholly racemic compounds: *i*-*iso*menthone
10. *Ld*,*Dl* } and *i*-menthone, respectively.

We are continuing the detailed investigation of the whole field of work indicated in this paper.

A CONTRIBUTION TO THE CHEMISTRY OF THE PHELLANDRENES.

By ERIC HURST, HENRY GEORGE SMITH, and JOHN READ.

[*Read before the Royal Society of N. S. Wales, November 1, 1922.*]

IN the course of his well-known investigations on the phellandrenes, Wallach established the complete chemical and physical identity of the dextro-gyrate phellandrene of elemi oil with the dextro-gyrate phellandrene of bitter fennel oil. Further, the lævo-gyrate phellandrene of the essential oil of the so-called *Eucalyptus amygdalina* was characterised by him as the optical antipode of the first-named phellandrene. These phellandrenes were accordingly named *d*-α-phellandrene and *l*-α-phellandrene, respectively, whilst the dextro-gyrate phellandrene of water fennel oil was named *d*-β-phellandrene (Annalen, 1904, *336*, 9; "Terpene und Campher," 1914, 486).

The characterisation of these very closely related terpenes was accomplished largely by a study of their nitrites: these are well defined crystalline derivatives, easily obtained by the action of nitrous anhydride upon solutions of the hydrocarbons in light petroleum at 0°. Schreiner (Pharm. Arch., 1901, 90; Chem. Soc. Abstracts, 1901, *80*, i, 600) showed that the *l*-α-phellandrene of eucalyptus oils yielded in this way a mixture of two nitrites having distinct melting points and optical rotatory powers. In confirming Schreiner's observation, Wallach isolated an α-nitrite, melting at 113–114° and a β-nitrite, melting at 105°, from the lævo-gyrate α-phellandrene of eucalyptus oil. The melting point recorded by Schreiner for the less soluble α-nitrite was, however, 120–121°; so that a considerable

discrepancy exists between the two temperatures quoted for the melting point of this substance.

Wallach states (*loc. cit.*, p. 16) that although mixtures of the α- and β-nitrite show little change in melting point, as compared with the pure substances, it is nevertheless easy to discriminate between the two individual substances and their mixtures by observations of optical rotatory power. According to Wallach, the α-nitrite of *l*-α-phellandrene (from eucalyptus oil) in chloroform solution gave $[\alpha]_D$ +142·6° and $[\alpha]_D$ +135·93°, whilst Schreiner obtained the value $[\alpha]_D$ +123·5°. Similarly, for the corresponding β-nitrite Wallach recorded the values $[\alpha]_D$ −40·817° and $[\alpha]_D$ −40·287°, whilst Schreiner obtained $[\alpha]_D$ −36° for a preparation melting at 100 − 101°. Values closely corresponding in magnitude were recorded for the two nitrites prepared from the *d*-α-phellandrene of bitter fennel oil, the sense of the optical rotation being, of course, reversed.

The extremely important role of the nitrites, in a study of the chemistry of the phellandrenes, need not be elaborated further for the purposes of the present paper.

During investigations on components of the essential oil of *Eucalyptus dives* we were led to prepare specimens of the nitrites of the *l*-α-phellandrene of which this oil is so notable a source. As a consequence, it was found possible to isolate without difficulty specimens of *l*-phellandrene α-nitrite melting at 121 − 122°, with decomposition. Such specimens, when dissolved in chloroform to form solutions of the approximate concentration indicated by Wallach, and submitted without delay to polarimetric examination, yielded results agreeing satisfactorily with the values quoted above. It was noticed, however, that the originally colourless solutions became pale yellow and finally brown, or reddish-brown, when kept. Polarimetric examination showed that the change in colour was in all instances

accompanied by remarkable changes in the magnitude, and even the sense, of the optical rotatory power. The following selection from an extensive series of observations is sufficient to indicate the pronounced mutarotation which occurs not only in chloroform solution but also when the substance is dissolved in other organic solvents:—

1. *l*-α-Phellandrene α-nitrite (m.p. 121 – 122°): 0·7517 gram dissolved in chloroform and made up to 30·0 c.c. at 20°.

Time	$[\alpha]_D^{20}$	Time	$[\alpha]_D^{20}$
8 mins.	+137·7°	4 hours	+81·0°
14 ,,	+136·9	25 ,,	−23·5
20 ,,	+135·1	48 ,,	−24·0
57 ,,	+125·3	121 ,,	−70·0
158 ,,	+99·8	144 ,,	−70·0

2. *l*-α-Phellandrene α-nitrite (m.p. 121 – 122°): 0·3762 gram dissolved in benzene and made up to 30·0 c.c. at 20°.

Time	$[\alpha]_D^{20}$	Time	$[\alpha]_D^{20}$
5 mins.	+234·4°	23 hours	+65·8°
6 ,,	+232·9	95 ,,	−42·7
20 ,,	+220·9	167 ,,	−87·3
40 ,,	+209·7	333 ,,	−103·3
75 ,,	+189·0	355 ,,	−103·3

3. *l*-α-Phellandrene α-nitrite (m.p. 121 – 122°): 0·5014 gram dissolved in acetone and made up to 30·0 c.c. at 20°.

Time	$[\alpha]_D^{20}$	Time	$[\alpha]_D^{20}$
8 mins.	+165·3°	21 hours	+67·0°
14 ,,	+164·1	70 ,,	+12·2·
20 ,,	+162·7	98 ,,	−7·0
60 ,,	+154·8	335 ,,	−38·1
90 ,,	+150·8	359 ,,	−38·1

Thus, with all three solvents optical inversion occurred with lapse of time. These observations have, therefore, an important bearing upon the application of the nitrite

reaction for the diagnosis of phellandrenes in essential oils, as well as possessing a much more general interest in connection with the chemistry of the terpenes concerned.

It may be added in this place that certain physical and chemical agencies have been found to exert a pronounced acceleration on the velocity of mutarotation. Further, the β-nitrite of *l*-α-phellandrene appears to exhibit somewhat similar changes. The enquiry is also being extended to nitro-α-phellandrene. These observations will be recorded fully in subsequent publications, together with the results of a comparative physical and chemical examination of phellandrenes obtained from other sources, including various species of Eucalyptus and allied Australian genera.

We are continuing the detailed investigation of the whole field of work indicated in this paper.

NOTES ON THE CHEMISTRY OF CERTAIN AUSTRALIAN PLANT PRODUCTS, PART I.

By HENRY GEORGE SMITH.

With Plate VI.

[*Read before the Royal Society of N. S. Wales, November 1, 1922.*]

DURING the long period throughout which the writer occupied the position of Economic Chemist to the Sydney Technological Museum many chemical problems connected with Australian plants were submitted for investigation. The present notes are designed to place on permanent record a number of results obtained in this way, and which for various reasons have hitherto remained unpublished. It should be added that in every instance the writer is indebted to his colleague, Mr. R. T. Baker, F.L.S., for botanical assistance.

1. *Resin coating the leaves of Acacia verniciflua.*

The material for investigation was sent from Eden, New South Wales, by Mr. W. Stafford. As received, the foliage was cemented together with a sticky glutinous material which had exuded from the leaves and terminal branchlets, and which proved to be a resin consisting of resin acids and neutral resins in approximately equal proportions. Although the resin was soft, it is doubtful whether it contained any essential oil at the time of examination. Resin is a very unusual constituent in members of the N.O. Leguminosæ, the principal secretion in this group of plants being rather of a carbohydrate nature.[1] It has been suggested, however, that under certain conditions tannin may

[1] See in this connection Solereder, Vol. I, page 292, for resin from *A. dodonæifolia*.

be an intermediate product in the formation of resin, and the Acacias as a group are well known to secrete considerable amounts of tannin. Whether the formation of resin in this particular case may also be ascribed to the prior existence of tannin, or of polymerised and oxidised hydrocarbons, can only be determined by systematic chemical studies continued for a sufficient period.

The resin in question was readily soluble in alcohol, and almost entirely so in ether. In order to effect its isolation, the leaves and terminal branchlets (76 grams) were immersed for several periods of one hour in successive small amounts of alcohol. After filtering the mixed alcoholic extracts, which possessed only a pale brown colour, the solvent was expelled by evaporation followed by drying at 105°. The residual resin (11·2 grams) amounted to 14·7 per cent. of the weight of the original material. The resin was treated with ether, in which most of it dissolved. The filtered ethereal solution was next rendered slightly alkaline with alcoholic potassium hydroxide; the mixture was then diluted with an excess of water, and shaken in a separating funnel with ether, in order to extract the uncombined resin. The neutral resin recovered from this ethereal extract represented 45·5 per cent. of the total resin. The aqueous solution was heated to expel the ether, and then acidified with hydrochloric acid. The resin acids obtained in this way amounted to 34·9 per cent. of the total resin. The quantity of tannin extracted by the alcohol was insignificant, and the aqueous filtrate from the precipitated resin did not reduce Fehling's solution, thus indicating the absence of reducing sugars. I am indebted to Mr. F. W. Byrne for assistance in the determination of this resin.

2. *Essential Oil of Bœckea Gunniana.*

The material for distillation was obtained in the month of March, at Mount Kosciusko, New South Wales, by Mr.

L. G. Irby: 160 lbs. of leaves and terminal branchlets gave 5½ oz. of oil, equal to 0·214 per cent.

The crude oil was reddish, owing to the action of phenolic constituents on the iron digester during the process of distillation, and it had a decidedly unpleasant odour reminiscent of certain terpenes. Nearly 50 per cent. of the oil consisted of dextro-rotatory pinene, whilst the less volatile fraction was composed largely of a sesquiterpene; cineole was also present in small amount.

The specific gravity of the crude oil at 15° was 0·9172; optical rotation α_D +8·4°; and refractive index at 19° 1·4856. On distillation, 46 per cent. came over at 153–170°; 26 per cent. at 170–200°; and 18 per cent. at 240–265°. These three fractions gave the following results:—

Fraction.	Sp. gr. at 15°.	α_D.	n_D^{15}.
153–170°	0·8725	+15·6°	1·4723
170–200	0·9104	+6·6	1·4800
240–265	0·9477	+1·2	1·5133

After redistillation, the first fraction yielded a nitrosochloride melting at 103–104°, thus indicating the terpene to be pinene. Cineole, determined by the resorcinol method in the oil distilling below 200°, amounted to 9 per cent., calculated on the crude oil. The saponification number for the esters together with the free acid was only 5·5, so that esters were only present in small amount. Phenolic constituents were extracted from the crude oil by agitation with a 5 per cent. aqueous solution of potassium hydroxide in the usual way. Only a very small quantity of a liquid product was thus obtained; this gave a persistent reddish colour with ferric chloride. Tasmanol, the liquid phenol of eucalyptus oils, gives a similar test. A small amount of an aldehyde was removed by shaking the phenol-free oil with a saturated solution of sodium bisulphite. The aldehyde had an odour resembling that of cinnamic aldehyde, but the amount isolated was insufficient to allow of accurate

characterisation. No sign of a crystalline constituent was detected in this oil.

3. *Rubber and Wax from Sarcostemma australe, N.O. Asclepiadaceæ.*

This plant, which occurs in all the Australian States except Victoria and Tasmania, is known as "Caustic Vine," or "Caustic Plant." The material was forwarded to the Technological Museum by Messrs. Faulding and Co., of Adelaide, and was collected in Central Australia.

The leafless stems were pea-green in colour, and coated with a silvery, bronze-like material, loosely attached to the stem, easily removed, and containing a fair amount of a vegetable wax. The thickest stems of the material received had a diameter of about 8 mm.; whilst the bark-like portion was about 1 mm., and the wooden, pipe-like portion just over 1 mm. in thickness. The central, pipe-like stem, when freshly cut, was filled with a delicate fibrous material through which the latex travelled. When dry, this spongy matter shrivelled up, leaving the stem with a central channel which in section resembled a pipe-stem. As the specimen when received had been collected for some time, it had partly dried, but even so the central channel still contained a quantity of the milky latex, which exuded when the stem was cut. The latex, which was also circulating through the bark-like portion of the plant, was of the consistency of milk and very adhesive. The small amount of material received did not produce sufficient latex for an exhaustive examination, although the results obtained give a very good idea of the amount of rubber likely to be derived from the plant, and of the general character of its chemical products.

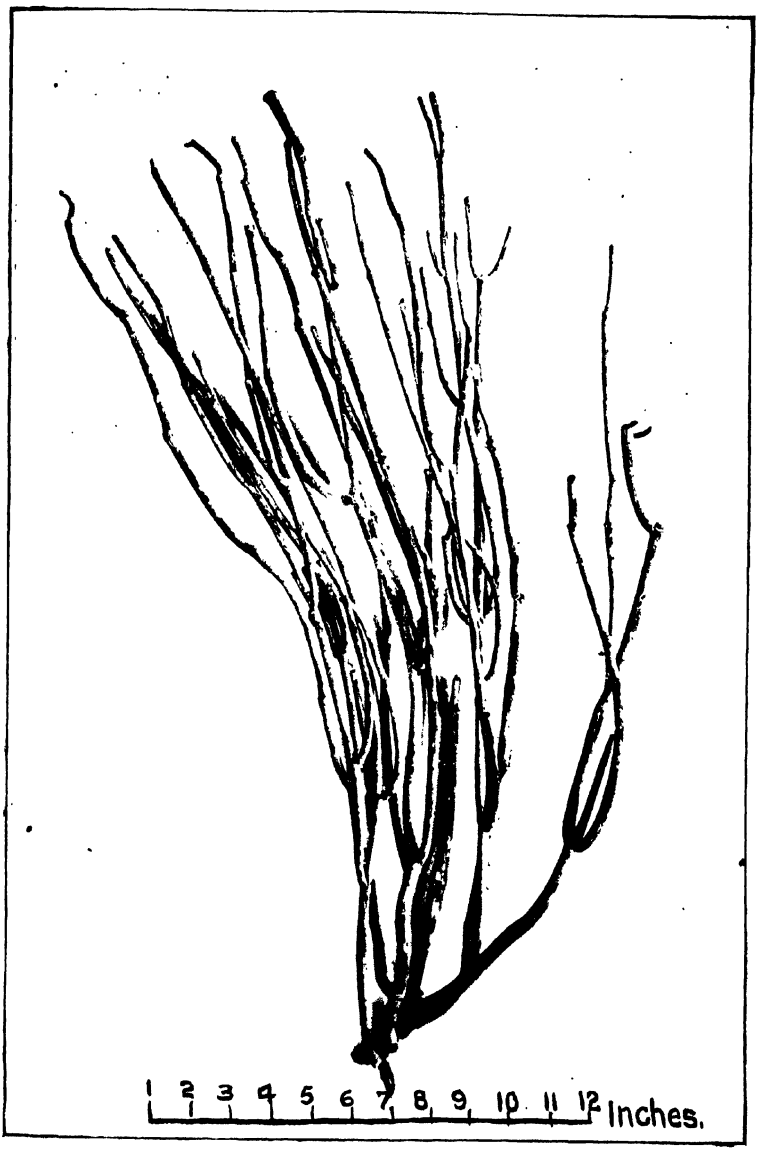
The stems were cut into short pieces and the latex collected. It was then coagulated with acetic acid, and the coagulated mass, which represented about 16 per cent. of the latex, was well washed with water and air-dried. It was thereupon dissolved in chloroform, and the filtered solution evaporated so as to form a film on a glass vessel. This film, which was of a rubber-like consistency, was

treated with acetone, in which the resinous portion easily dissolved. The remaining rubber, representing about 7 per cent. of the latex, was elastic, and although somewhat soft had all the properties of a caoutchouc. The portion soluble in acetone was white, easily powdered, and melted to an almost colourless resinous mass.

Whether this Australian plant could be economically utilised for the rubber it contains can only be decided by further systematic investigations, but it would not be possible to collect the latex by incisions in the stems. It would be necessary to treat the whole plant by solvents, or by mechanical means, as in the case of "Guayule Rubber" btained from *Synantherea Mexicana*—the coagulated rubber from which plant also contains a high percentage of resins, although the rubber itself is of fair quality.

The wax which occurs on the outside of the stems was not easily soluble in ether or in cold alcohol, but was soluble in boiling alcohol, from which it separated as the solution cooled. Purified in this way, the wax melted at 79°, in a capillary tube in water. This is a somewhat high melting point for a vegetable wax, so that, if obtainable in quantity, this product should have commercial value.

The accompanying illustration of the material worked upon indicates that *Sarcostemma australe* grows as a leafless shrub, although it is described in the Flora Australiensis as a twiner. That the plant assumes both forms of growth has already been shown, and Tate (Journ. Proc. Roy. Soc., South Australia, IV, 136) describes it as a shrub two or three feet high, growing on the granitoid-felstone cliffs about Tickera, S.A., and also as a twiner in other localities (same Journ., v, 9). Mr. S. Dixon (same Journ., VIII, 26) also describes it as growing in the bush form with stems scarcely as thick as a penholder, and states that in the North Western districts sheep have lived upon it for months without water; a similar statement is also made by Max Koch (same Journ., XXII, 114). The above authors also describe the use made of the latex by the aborigines and others as a remedy for healing sores.



SARCOSTEMMA AUSTRALE, R.Br.

NOTES ON PLATE EXPOSURES, AND THE SUBSEQUENT PHOTOGRAPHIC TREATMENT ADOPTED BY THE SYDNEY UNIVERSITY ECLIPSE EXPEDITION.

By EDGAR H. BOOTH, B.Sc.,

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[With Plates VII—VIII.]

[*Read before the Royal Society of N. S. Wales, November 1, 1922.*]

A very important portion of the work of any Eclipse Expedition is photographic. Indeed, photographic methods are of great value in any branch of scientific work in which they can be employed, on account of the possibility of obtaining a permanent record for later analysis.

The cameras at our disposal for photographs of the corona were varied both in their magnifications and in their adaptability for the work in hand, but were so altered and adjusted as to cover a wide range of inner and outer corona work.

This paper is concerned purely with the exposures and photographic treatment, but a brief description of the apparatus employed by the various members of the expedition is essential. It comprised:—

(1) The Sydney University Cecil Darley Telescope, rigidly mounted horizontally as a coronagraph of equivalent focal length of sixteen feet, fed by a coelostat, and intended for work on the inner corona and prominences. Owing to slight distortion, only a diameter equivalent to 1·8 solar diameters could be relied on to give a dependable image, so a diaphragm was inserted to cut it down to that plate area. Half-plate slides were employed, the plates being Imperial Special Sensitive, backed.

The solar image had a diameter of 1·7 inches, and the equivalent stop was *f* 64.

(2) An aeroplane camera of focal length twenty inches and stop *f* 6·3, with an adjustable K 3 filter. The camera was equatorially mounted.

This instrument was lent for the purpose by the Military Board, and was adapted by the Expedition to give time exposures, and to feed as a magazine camera pointing upwards instead of downwards. The plates were Ilford Special Rapid panchromatic, size $5 \times 3\frac{7}{8}$ inches.

(3) A box camera specially constructed for this work, of focal length forty-five inches and stop *f* 13, equatorially mounted with and alongside the aeroplane camera. The lens was a rapid retilinear, and should apparently have been stopped down, as the eclipse image was not as sharp as trial plates had indicated. The plates employed were Imperial Special Sensitive, backed.

The first difficulty experienced was to obtain some idea as to the relative time of exposures for inner and outer corona, and the absolute time of exposure for either of them. A careful search of earlier records showed that the time of exposure varied considerably with different writers, and that the same exposure at different eclipses appeared to give widely different results. It was decided, therefore, to work on the principle that provided the matter required was on the plate, *i.e.*, provided a sufficiently long exposure was given, it could be handled as required in developing or in printing. Consequently full exposures were to be desired, the limitations being the necessity of exposing several plates for different effects, and the possibility of inaccuracy of movement of the coelostats or equatorial mounting. The mean exposure decided on was the equivalent of 10 seconds at *f* 8 for outer corona work, and 0·5 second at *f* 8 for inner corona work. When a number of

photographs were taken by one instrument, the exposures were spaced on either side of these values.

The sixteen foot Cecil Darley telescope described under (1), and operating at *f* 64, was used for six exposures, the times being 3, 6, 12, 24, 48, and 12 seconds. It will be noticed that the "doubling up" principle was employed—modern plates have such a wide latitude that any smaller change of exposure ratio than two is unnecessary. The coelostat worked excellently, and the six plates were successfully exposed.

All development was carried out at the University, the developer employed being the laboratory standard Metol-Quinol.[1] A six tray method was employed, the third tray being a 1:32 mixture (normal). The first tray was 1:128 (very weak), the second 1:64 (weak), the fourth 1:16 (strong). The fifth tray contained a 1:1000 solution of potassium bromide, and the sixth tray pure water. The plates were developed singly, after the backing had been removed by washing. The dark room illumination was a No. 2 Wratten Safelight for the special sensitive plates, and a No. 3 Wratten Safelight for the panchromatic plates. Placed first in No. 1 tray, the time of first appearance of image was noted. Plates in which the image showed up in from 60 to 90 seconds were considered normal, and transferred to No. 3 tray, development taking normally a further five minutes. Plates on which the image showed up in less than 60 seconds were transferred to No. 5 tray (KBr) for a time from 10 to 90 seconds, depending on the degree of overexposure, then to No. 6 tray where development took about an hour. Those plates on which the image took longer than 90 seconds to appear were transferred to No. 4 bath for two minutes, then to No. 6 tray for about an hour, or till general fog began.

[1] Booth, Aust. Photo. Review, Vol. 29, p. 16. British Journal of Photography, Vol. 69, p. 168.

By this means all plates were satisfactorily "over-developed"—that is everything possible was developed out on the plate, to the point of general chemical fog. The temperature was maintained at from 65 – 70° F. throughout.

All plates after fixing (Hypo. 1:5) were briefly washed, given an alum bath, washed for half an hour, and allowed to dry without forcing.

On examination it was found that the best exposure—inner corona, *f* 64—was 24 seconds. This plate contained more detail than those of shorter exposure, and nothing had been gained in the 48 second exposure. Owing to the method of development and the latitude of the plates, all were quite satisfactory. An exposure of 3 seconds, *f* 64, was ample for the prominences; in the plate of that exposure, No. 1 (consequently showing prominences on sun's eastern limb at second contact), they were fully exposed, and developed to maximum contrast.

The images were quite sharp, prominences and polar streamers being excellently delineated.

The plates from the equatorially mounted aeroplane and box cameras were similarly developed. These plates were intended to show the outer corona, and to extend the streamers as far as photographically practicable. The exposures with both cameras were 1, 3, 10, 30, 60, and 36 seconds. For the last exposure (36 seconds) the colour screen was in position on the aeroplane camera. The 60 seconds *f* 6·3 was definitely overexposed—there was evidently nothing to be gained by going beyond 30 seconds, which showed a maximum length of streamers (three solar diameters). The 36 seconds screened exposure was remarkable in so far as the greater portion of general sky illumination was cut out, giving much greater coronal contrast. The main portion of the coronal illumination was extended to a much greater distance than recorded on any of the

other plates. The use of the screen in conjunction with panchromatic plates would appear to give interesting results—one is sorry that an exposure was not made on the 16 foot coronagraph by this method, for the inner corona. The one and three seconds were definitely underexposed, except for inner corona—probably a 20 seconds exposure *f* 6·3 would have been best, although there was very little difference between the 10 and 30 seconds. The images were quite sharp, showing no sign of movement even in the 60 seconds exposure, and permitting enlargement up to ten diameters, beyond which the grain of the plate spoils all detail.

The box camera plates were not so satisfactory—the images were not so sharp and streamer definition not so good, though again extending out to three solar diameters. Considering the sharpness of the lunar image in trial plates, it is considered that possibly some slight movement of the slide holder with respect to the focal plane took place after rehearsal, and prior to the eclipse. The 30 seconds exposure *f* 13 was quite satisfactory and would, with the aeroplane camera results, seem to point to an exposure of the order 20 seconds *f* 8 as being the best for outer corona work.

Having now a good collection of negatives, it was required to obtain prints showing everything that was included in the plates. It is well known that the best detail is seen in the original negative itself—it is not possible to produce an uncontrolled print in which so much can be seen. For the examination of the plate, therefore, or for exhibition, it is best to print off transparencies, on the slowest and heaviest emulsion obtainable.

The transparencies consisting of silver deposits in gelatine, the thickness of the silver layer being a function of the incident light value, and being viewed by transmitted

light, allows detail to be seen in both the densest and clearest portions at the same time.

If a print be taken from the negative, however, the picture is viewed by reflected light, the actual light penetration being slight, and consequently the range of contrasts must be slight also.

Whilst, therefore the negatives may, and do, show the prominences, the fine polar streamers, and the main coronal detail all at the same time, it is not possible to reproduce these all sharply on the one print. A transparency is much better, as already explained; but to get the maximum value from the negative it is imperative that a series of prints should be made. The effect is the same as though many plates of widely differing exposures had been taken.

The plates of the Sydney University Eclipse Expedition have been treated in this manner, the best plates being taken as the basis of a series of prints.

As a concrete example, the plates of greatest interest in the case of the 16 foot coronagraph are the first (just after second contact), the sixth (just prior to third contact), and one intermediate plate (the third was chosen). Prints were taken from these on Velox Glossy Regular paper, the exposures being on the "double up" principle. The developer used was the laboratory standard Metol-Quinol 1:15, plus two drops of 10% solution of potassium bromide per ounce of mixture. The prints were fixed in hypo (1:5), rinsed, hardened in an alum bath, and ferrotyped after washing. The actual times of exposure of course depended on the negative, but the relative values will be seen from one case, particulars of which are set out in Table I. The "dull light" referred to was an 8 c.p. carbon filament, the "bright light" a 300 c.p. half watt lamp. "Close" was 9 inches, "far removed" was 3 feet.

Table I, Plate No. VI.

Print No.	Exposure.	Remarks as to Light.	General Remarks.
1	5 minutes	Dull light, far removed	To bring out as much general detail as possible over the whole field.
2	15 seconds	Bright light, close	Printed whole of negative.
3	30 seconds	Bright light, close	Outer portion of corona blacked out—shows up polar streamers well.
4	1 minute	Bright light, close	More of corona blacked out, carries detail of corona further in.
5	2 minutes	Bright light, close	Polar streamers close in, prominences showing well through inner corona.
6	4 minutes	Bright light, close	Prominences only showing.

To examine these six prints is to see all that the negative can give; one has the effect of six different negatives, each giving the best exposure for one particular portion of the corona. Six prints were taken from each of negative I and VI, whilst from plate III, three were all that were desired at present, (two, of maximum and minimum exposure respectively, and one of intermediate exposure).

The photographs illustrating this paper correspond to prints 1, 3, 4, and 6 of Table I. No enlargement work has so far been carried out with this set of negatives.

The same process has been applied to the photographs taken with the aeroplane camera; in addition, a number of enlargements have been made which are quite instructive. A composite inner and outer corona picture is being made from one of the aeroplane camera plates enlarged

till its solar diameter is the same as that of the 16 foot camera, together with the corresponding plate from the latter instrument.

The box camera records are not sufficiently sharp to be of any use for inner corona work—consequently they are being employed for outer corona measurements, including extreme recorded length of streamers.

Another point of interest is the spreading of the exposures over the full time of totality—the moon moved approximately from the western to the eastern edge of the sun, so naturally the prominences at the eastern limb could be photographed only immediately after second contact, and the prominences at the western limb only immediately before third contact.

If allowed to repeat the performance, the following exposures and spacing would be adopted for inner corona photographs, *f* 64 :—

Plate No	Exposure	Time of commencement of Exposure.
1	3 seconds	1 second after second contact.
2	12 ,,	20 ,, ,, ,, ,,
3	24 ,,	1 minute ,, ,, ,,
4	48 ,,	1 minute 40 seconds after second contact
5	12 ,,	35 seconds before third contact.
6	3 ,,	10 ,, ,, ,, ,,

This is, of course, counting on a totality of three and a half minutes—if shorter, plates 2 and 5 would be the first cut out.

The Physical Laboratory,
The University of Sydney.

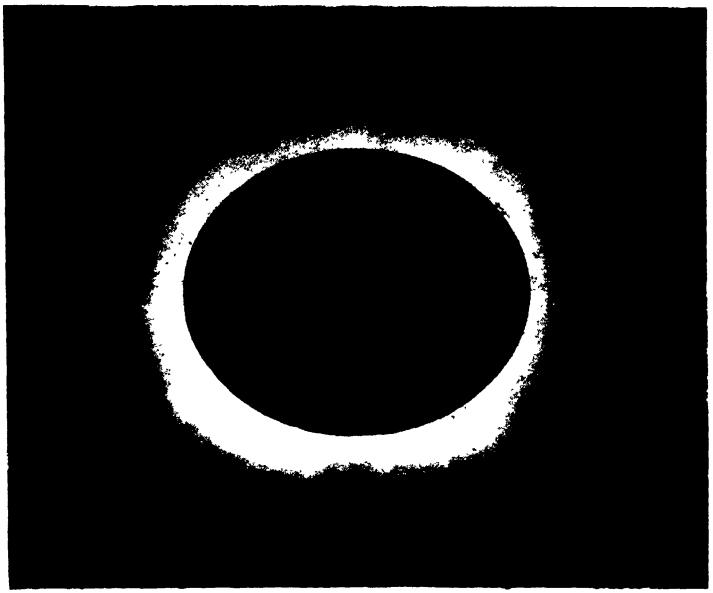


Fig. 1

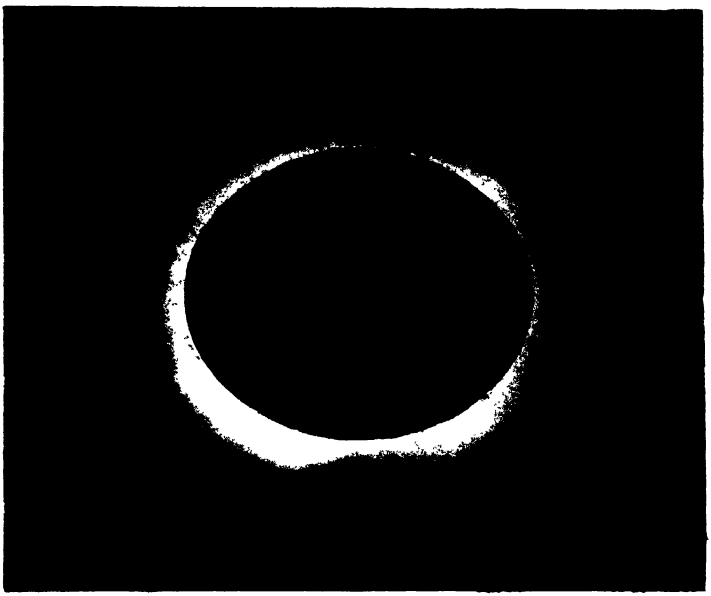


Fig. 2

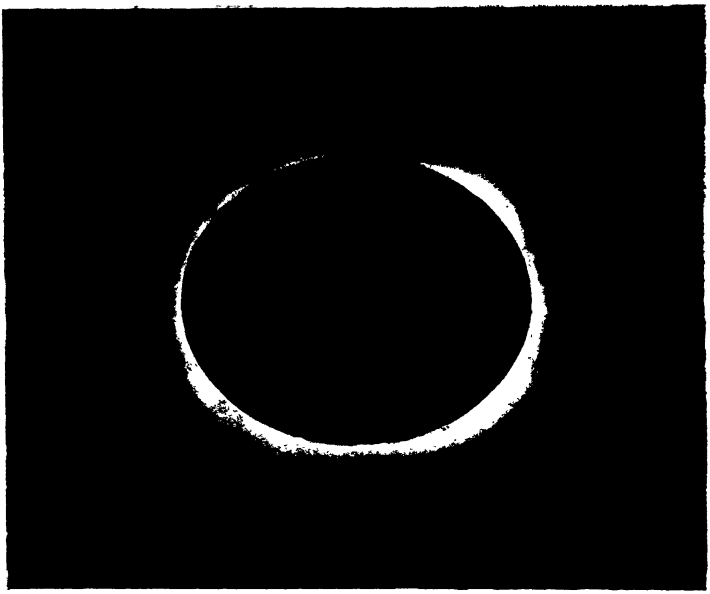


Fig. 3



Fig. 4

THE ESSENTIAL OILS OF TWO SPECIES OF HOMORANTHUS AND THE OCCURRENCE OF OCIMENE.

By A. R. PENFOLD, F.C.S.

Economic Chemist, Technological Museum, Sydney.

[*Read before the Royal Society of N. S. Wales, November 1, 1922.*]

THE essential oils herein detailed were obtained from the leaves and terminal branchlets of *Homoranthus virgatus* and *H. flavescens*, both of which were described by Allan Cunningham when establishing the genus Homoranthus in 1840 (Schau. Myrt. Xeroc. 191, t. 3, 1840). Later botanists, such as Mueller and Bentham united the two species under *H. virgatus*, considering them to be identical. The botany of these interesting Myrtaceous shrubs has been under careful observation by Mr. E. Cheel of the National Herbarium, Sydney, for some years, with the result that they are again separated and considered quite distinct species. The botanical description, together with key, distribution, and bibliography of both of them is fully described by this worker in this Journal, "Notes on the genera Darwinia Homoranthus and Rylstonea in New South Wales, Queensland, and South Australia," on pages 63, 69, 75 – 77.

The examination of the essential oils confirms in a most striking manner the individuality of the two species, the first named yielding an oil containing up to 80% d-α-pinene, and the other the same quantity of ocimene, two bodies of entirely different properties and constitution, and bearing no relation to one another. The author has also had the opportunity of seeing both species in the field, and was much impressed by the characteristic habit of *H. flavescens*

of spreading out fan-like about 18 inches from the ground, a totally distinct feature from that of *H. virgatus* growing upright to approximately 4 feet. It also produces an abundance of richly honeyed flowers of a bright yellow colour crowded towards the tips of the branchlets. This viscous secretion, which readily spoils the trousers of the wearer passing through a field in full bloom, is also being investigated in this laboratory.

Homoranthus virgatus.

Material of this slender upright shrub, which is very widely distributed in the Northern Rivers District of New South Wales and Southern Queensland, was procured from Broadwater and Woodburn, both of New South Wales, and Stradbroke Island, Queensland, a total of 325½ lbs. being obtained. The percentage yield of crude oil averaged about 0·7%, varying from 0·35% to 0·97%, the lower yield being due to collection during the winter months.

The Essential Oil.

The essential oils obtained from the three consignments of leaves from localities, as enumerated, were of a pale yellow colour, with the exception of the Woodburn sample which was somewhat reddish, quite mobile, and possessed a pleasant terpenic odour reminding one of the oils of Darwinia.

The principal constituents, so far determined, were found to be d-α-pinene (up to about 80%), the balance consisting largely of a sesquiterpene identical with those isolated by the writer from other Myrtaceous oils, with small amounts of amyl alcohol, isovaleric aldehyde, and a paraffin of M.Pt. 65–66° C.

Experimental.

325½ lbs. weight of leaves and terminal branchlets from the districts mentioned, yielded on distillation with steam

crude oils, possessing the chemical and physical characters shown in table:—

Date.	Weight of Leaves.	Locality.	Percentage Yield.	Specific Gravity 15/15° C.	Optical Rotation.
3/9/1917	26 lbs.	Broadwater	0·97%	0·8660	+28°
12/5/1922	130 lbs.	Woodburn	0·35%	0·8927	+20°
3/10/1922	169½ lbs.	Stradbroke Island, Q.	0·76%	0·8809	+18·5°

Refractive Index. 20° C.	Solubility in 80% alcohol (by weight).	Sap. No. 1½ hours hot.	Sap. No. 1½ hrs. hot after acetylation.
1·4743	insoluble in 10 vols	6·16	27·65
1·4818	ditto	6·11	43·17
1·4801	ditto	6·03	31·80

On distillation, the crude oils behaved, as follows:—

3/9/1917 80% distilled below 180° C. at 762 mm.

12/5/1922 50% came over between 50–70° C. at 10 mm.; 8% distilled between 70–120° C.; and 36% between 121–133° C.

3/10/1922 55% distilled below 60° C. at 10 mm.; 14% between 60–100° C., and 28% came over between 120–135° C. at same pressure.

Determination of the principal Terpene.—On repeated redistillation of the first lower boiling fractions, both at 10 mm. and at atmospheric pressure, the greater portion, about 90%, distilled below 160° C. at 772 mm., and was found to consist principally of d-α-pinene. It possessed the following characters, viz:—Boiling point 155–157° C., specific gravity $\frac{15}{15}$° C. 0·8627, optical rotation +40°, and refractive index 16° C. 1·4666. Its identity was confirmed by the preparation of pinonic acid:—32 c.c. were shaken with 67 grams potassium permanganate, 800 c.c. water, and 450 grams ice until the reaction was completed. On removal of manganese sludge, the liquid was steam distilled to remove unchanged terpene, and evaporated to a small bulk. It was then acidulated with dilute sulphuric acid,

and extracted with chloroform. On removal of solvent the pinonic acid distilled at 176 – 182° C. at 5 mm., and became semi-solid on standing overnight at room temperature. The crystals were separated and purified from petroleum ether. They melted at 68 – 68·5° C. On repeated recrystallisation specially picked crystals could be obtained of M.Pt. 70° C. The semicarbazone of the acid melted at 207° C. 0·2502 grams of the acid in 10 c.c. chloroform gave $[\alpha]_{D\ 17°\ C.}$ +90°.

Other Terpene.—During the fractionations smaller portions of oil were obtained boiling from 160° C. up to 175° C., more particularly in the Stradbroke Island sample, the quantity in this case being equal to about 50% of the terpene fraction. Careful examination showed the absence of nopinene, and it appeared to consist principally of d α pinene contaminated with a small amount of other terpene very difficult of separation. A comparison of the physical constants showed that as the boiling point of the respective fractions increased, the specific gravity and optical rotation decreased, whilst the refractive index went up, thus tending to show that the other terpene had a boiling point of about 170 – 176° C., low specific gravity, high refractive index, and was inactive. Repeated attempts at identification resulted in failure, but in view of the closely allied species containing ocimene, it is quite likely that it may be identical therewith.

Determination of Sesquiterpene.—The highest boiling fractions were repeatedly distilled over metallic sodium at 10 mm., and although sufficient oil was not available for large quantities to be used, the following fairly constant fractions were obtained :—

	Woodburn Sample.	Stradbroke Island Sample.
Boiling point at 10 mm.	129 – 132° C.	129 – 132° C.
Specific gravity at $\frac{15}{15}$° C.	0·9171	0·9188
Optical rotation	inactive	– 2·25°
Refractive index 20° C.	1·5049	1·5040

These fractions beyond giving the usual colour reactions with bromine vapour and sulphuric acid in acetic anhydride solution, did not yield any of the solid derivatives typical of sesquiterpenes. The sesquiterpene appears to be identical with that isolated from the various Leptospermum oils described by the writer, and assumed to be identical with eudesmene.

Minor Constituents.—In the course of the examination of the crude oils the following minor constituents were detected, but were not present in sufficient quantity to enable their identity to be confirmed :—Woodburn sample, amyl alcohol and paraffin. Stradbroke Island sample, isovaleric aldehyde and paraffin of melting point 65 – 66° C.

HOMORANTHUS FLAVESCENS.

Material of this low decumbent shrub was collected from one locality only, the State Forests at Narrabri, N.S.W., for the whole of which I have to thank the Forestry Commission of New South Wales, and particularly Mr. Gordon Burrow the District Forester, through whose kindly interest and assistance such excellent supplies were furnished.

The percentage yield of crude oil averaged 0·55%, varying from 0·35% to 0·82%, the lower yield being from material collected at the close of winter, the higher being attained about the middle of summer.

The Essential Oil.

The essential oils obtained from three consignments of leaves were of a pale straw colour, particularly mobile, and possessed an odour peculiar to themselves characteristic of the hydrocarbon ocimene, modified by the presence of small amounts of amyl alcohol, and its acetic and butyric acid esters. During the winning of the oil these low boiling constituents came through the condenser first, and rapidly diffused through the still room giving the charac-

teristic odour of bananas. Very often on crushing the leaves in the field the first odour detected is that of bananas. The principal constituents, so far identified, have been found to be the olefinic terpene, ocimene, occurring to the extent of up to 80%, d α pinene and sesquiterpene, together with the minor constituents mentioned above.

This is the first recorded occurrence of the presence of ocimene in an Australian essential oil, and so far as the writer is aware, is most probably now its richest source. The oil and ocimene content of the plant varies during the year reaching its apparent maximum about October to November. The plant appears to be affected by conditions of environment, as even in a comparatively dry district like Narrabri the plant appeared to be more luxuriant in one forest than in another. The writer feels confident that if grown in a district of rich soil, well supplied with moisture both the oil content and ocimene could be considerably augmented.

Experimental.

356½ lbs. of leaves and terminal branchlets from Narrabri, New South Wales, yielded on distillation with steam, the following crude oils, possessing the chemical and physical constants shown in table:—

Date.	Locality.	Weight of Leaves.	Percentage Yield of Oil	Specific Gravity at 15/15° C.	Optical Rotation.
26/9/21	Narrabri	97½ lbs	0·48%	0·8429	−1·75
18/10/21	ditto	140 lbs.	0·82%	0·8206	+1·5°
24/8/22	ditto	119 lbs	0·35%	0·8327	+2°

Refractive Index, 20°C.	Solubility in 80% alcohol (by Weight).	Sap No. Hot, 1½ hours.	Sap. No. hot, 1½ hrs. after acetylation.
1·4836	insoluble in 10 vols.	45·87	85·43
1·4873	ditto	9·46	51
1·4861	ditto	8·05	69·66

(The saponification numbers both before and after acetylation of the first distillation are quite abnormal, and not entirely due to the presence of actual ester and alcohol, but to some resinous

bodies, which appeared to increase in amount soon after distillation of the oil.)

On distillation at 10 mm. all three crude oils yielded from 81 – 85%, distilling below 77° C. at 10 mm., whilst the last two consignments gave 16 – 18% distilling between 123 – 142° C. at 10 mm. The first lot gave 11% distilling between 72 – 120° C., 12% between 120 – 160° C., leaving a resinous residue of about 14%, which no doubt partially accounts for the high ester and alcohol numbers.

Determination of d-α-Pinene.—Repeated fractional distillation at 20 mm., using a six disc column, of the portion of oil boiling below 77° C. at 10 mm. resulted in the partial separation of a small quantity of dextro-rotatory constituent distilling below 70° C. It had specific gravity at $\frac{15}{15}$° C. 0·8313; optical rotation from +8·7 up to +14·9°; refractive index at 20° C. 1·4746. It consisted of d α pinene together with ocimene, and readily gave a nitrosochloride, which on purification, melted and decomposed at 109° C.

Determination of Ocimene.—Many repeated fractional distillations conducted at 10 and 20 mm. were made, but it was found extremely difficult to remove the associated dextro-rotatory terpene, identified as d-α-pinene, despite the high content of the olefinic terpene. The best samples separated possessed the following characters:—

Boiling point at 10 mm. 67 – 68° C.
Boiling point at 20 mm. 75 – 76° C.
Specific gravity at $\frac{15}{15}$° C. 0·8034
Optical rotation inactive to +0·3°
Refractive index at 20° C. 1·4857 to 1·4859.

Its identity was established by the following experiments:

(1) The readiness with which it absorbed oxygen when spread on a watch glass. Instead of volatilising in the manner of a true terpene, it readily yielded a tacky resinous mass, which gave highly refracting emulsions with alcohol or water.

(2) On subjecting a sample of boiling point, 74–75° C. at 20 mm. to distillation over sodium at 757 mm., the first drops came over at 172° C., one-third of its volume distilling at 173–175° C., the remaining two-thirds boiling between 175–182° C., thus showing partial conversion into allo-ocimene.

(3) On reduction with sodium and alcohol dihydromyrcene was obtained in a moderately pure condition possessing the following characters:– Boiling point 68° C. at 20 mm. optically inactive; specific gravity at $\frac{15}{15}$° C. 0·790; refractive index at 20° C. 1·4511.

(4) The bromide of the above dihydromyrcene was prepared by dissolving the hydrocarbon in a mixture of one part amyl alcohol and two parts ether, as recommended in Parry's "Chemistry of Essential Oils," Vol. 11, page 68. On recrystallising from boiling alcohol it melted at 88–89°C.

Determination of Sesquiterpene.—The fractions boiling above 120° C. at 10 mm. were redistilled, finally over metallic sodium, but the quantity available did not permit of the isolation of the sesquiterpene in anything like a condition of purity, with the single exception of the last distillation. This was partly accounted for by the presence of resinous bodies in the first two lots, which is evident from the following table:—

	Boiling Point.	Specific Gravity.	Optical rotation.	Refractive index at 20° C.
26/9/21	136–140° C. at 5 mm.	0·9492 (17° C.)	–7·3°	1·5008
18/10/21	127–140° C. at 5 mm.	0·9333 (18° C.)	–1·6°	1·5018
24/8/22	133–135° C. at 10 mm.	0·923 ($\frac{15}{15}$° C.)	–4·25°	1·5040

The last mentioned is as pure a sample as was possible to be obtained. Precisely the same remarks apply here as stated under *H. virgatus* regarding the identification and colour reactions of the sesquiterpene isolated therefrom.

Minor Constituents.—Small quantities of amyl alcohol and its acetic and butyric acid esters were separated by

means of resorcin solution, but the amounts were too small to permit of the confirmation of their identity. It might be mentioned here that in order to obtain the terpenes in anything like a condition of purity it was necessary to remove these constituents by the procedure indicated.

In conclusion I have to thank the Director of Forests, Brisbane, for making the necessary arrangements for the collection of material of *H. virgatus* from Stradbroke Island, Queensland, and Mr. F. Morrison, Assistant Chemist, for his usual help in these investigations.

THE ESSENTIAL OIL OF KUNZEA CORIFOLIA.

By F. R. MORRISON,

Assistant Chemist, Technological Museum, Sydney

[*Read before the Royal Society of N. S. Wales, November 1, 1922.*]

THIS species, described by Bentham in "Flora Australiensis," Vol. III, page 115, is a dark green bushy shrub, and grows on the eastern coast of New South Wales, attaining a height of 5 to 15 feet. This is one of the commonest of the tea trees growing in the Port Jackson district, but owing to the rapid spread of population is not now so plentiful as formerly, nevertheless, luxuriant patches are still to be found quite close to Sydney. The material from which the essential oils were distilled for investigation was obtained from Gore Hill, Longueville, Waverley and Hornsby, all near Sydney.

The essential oil consists principally of d-α-pinene, a sesquiterpene closely resembling cadinene, together with

small amounts of ester and an unidentified alcohol, to which latter the characteristic fragrant odour of the oil is due.

The Essential Oil.

A total weight of 387 kilograms of leaves and terminal branchlets, cut as for commercial distillation, obtained from the localities enumerated, was submitted to distillation with steam and gave an average percentage yield of oil of about 0·35%, varying from 0·26 to 0·52%. The highest percentage yield was obtained from material collected at Waverley, on the sea-coast, the other localities being some distance therefrom.

Experimental.

The 387 kilograms of leaves and terminal branchlets gave on steam distillation crude oils possessing physical and chemical characteristics as follow:—

Date.	Locality from which material was obtained.	Weight of Leaves Kilos.	Percentage yield	Specific Gravity at 15/15° C.	Optical Rotation	Refractive Index at 20° C
27/1/1921	Gore Hill	154	0·26	0·9103	+ 18·6°	1·4902
10/10/1921	Waverley	174	0·52	0·9112	+ 12·0°	1·4893
20/7/1922	Longueville	22	0·32	0·9087	+ 24·0°	1·4837
5/10/1922	Hornsby	36	0·28	0·8917	+ 25·6°	1·4801

Ester No hot 1½ hours.	Ester No. after acetylation, hot 1½ h.	Ester No. after acetylation, cold 2 h	Solubility of Oil in 80% alcohol (by weight).	Colour of Oil.
13·0	49·22	...	insoluble in 10 vols.	Brown oil.
9·94	57·58	31·78	insoluble in 10 vols.	Dark brown oil
15·48	66·66	34·89	soluble in 10 vols.	Light green oil
13·56	39·19	15·57	insoluble in 10 vols	Light brown oil

The crude oils, on distillation, gave the following results: 27/1/21, 32% distilled between 40 – 50° C. at 10 mm.; 5% between 50 – 100° C. and 54% between 100 – 140° C. 10/10/21, 36% distilled below 185° C. at 762 mm.

Determination of the Terpene.—The lower boiling fraction in each case was submitted to repeated distillation, over 80% distilling below 160° C. at 766 mm. It was found:

to consist principally of d-α-pinene which gave the following constants:—27/1/21, boiling point 155 – 157° C., specific gravity $\frac{15}{15}$° C. 0·8613, optical rotation +40·6°, and refractive index 20° C. 1·4655. 10/10/21 boiling point 155 – 157° C., specific gravity $\frac{15}{15}$° C. 0·8623, optical rotation + 39·9°, refractive index, 20° C. 1·4651.

Confirmatory evidence of its identity was established by preparation of the following derivatives:—

On account of the high optical rotation the terpene failed to give a nitrosochloride; on mixing, however, with an equal volume of lævo-pinene $[\alpha]_D$ – 50·18°, which by itself failed to give a nitrosochloride, an excellent yield of the derivative was obtained which, when purified, melted at 104° C.

The hydrochloride, prepared by saturating 5 c.c. of the terpene at – 20° C. with dry hydrochloric acid gas, resembled camphor, and after recrystallisation from alcohol, melted at 127° C.

Oxidation of the Terpene.—58 c.c. were shaken with 120 grams of potassium permanganate, 1000 c.c. water, and 500 grams ice until completion of reaction. The liquid was passed through a suction filter whereby the manganese sludge was removed, and the clear liquid then evaporated to small bulk. It was then steam distilled in order to remove unchanged terpene, and again concentrated by evaporation. Dilute sulphuric acid was then added, the liberated pinonic acid extracted with chloroform, which latter solvent was distilled off, and the crude acid distilled at 5 mm. pressure, when the greater portion came over at 180 – 181° C. After standing for some considerable period crystals separated, and these were removed by filtration. On recrystallisation from petroleum ether the crystals melted at 68° C. 0·1704 gram of the pure acid dissolved in 10 c.c. chloroform rotated the plane of polarised light +1·7°. Specific rotation

$[a]_D$ + 100°. The semicarbazone was prepared and after recrystallisation from alcohol melted at 207° C. The terpene is therefore d-α-pinene.

Determination of the Sesquiterpene.—That portion of the Gore Hill sample of oil distilling between 100 – 140° C. (principally 120 – 140° C.), and the higher boiling portion of the Waverley sample were allowed to stand over metallic sodium for a week, and repeatedly fractionated over that metal until a main fraction was obtained, which possessed the following characters:—

Gore Hill—Boiling point 129 – 132° C. at 10 mm., specific gravity $\frac{15}{15}$° C. 0·9218, optical rotation +6°, refractive index at 20° C. 1·5056.

Waverley—Boiling Point 129 – 132° C. at 10 mm., specific gravity $\frac{15}{15}$° C. 0·9239, optical rotation −2·1°, refractive index at 20° C. 1·5046.

Preparation of the Hydrochloride.—5 c.c. of the sesquiterpene were dissolved in 10 c.c. of perfectly dry ether, the vessel placed in a mixture of ice and salt at −20° C. and the solution saturated with dry hydrochloric acid gas. It was allowed to stand overnight, when crystals separated. On recrystallisation from alcohol they formed beautiful needles melting at 115 – 116° C. 0·1162 gram dissolved in 10 c.c. chloroform gave optical rotation −0·65° $[a]_D$ −39·11°.

The sesquiterpene which gives a corresponding derivative with hydrochloric acid gas to that obtained as above, is cadinene which, according to Parry (Chemistry of Essential Oils, 2nd Edition, p. 73) possesses the following characters: Boiling point 272 – 275° C. at atmospheric pressure. Specific gravity 0·9215. Refractive index 1·5065. Optical rotation −105°. Melting point of dihydrochloride 117 – 118° C. and specific rotation in chloroform solution −37°.

Attempts to prepare the nitrosochloride and nitrosate were unsuccessful but the evidence so far obtained indicates that the sesquiterpene occurring in the oil is probably identical with cadinene.

Alcohols.—The saponification values after acetylation of the crude oils indicate the presence of fair quantities of alcoholic bodies in the oils. The only portion, however, in which these bodies appeared to be concentrated was a small fraction boiling between 160–185° C. This fraction was shaken with 50% resorcin solution, and on steam distillation 5 c.c. of a light blue oil were obtained which had the characteristic fragrant odour possessed to a lesser degree by the crude oil. The constituent thus obtained had the following characters:—Specific gravity $\frac{15}{15}$°C. 0·9029, optical rotation +6·2°, refractive index at 20° C. 1·4685.

Since the quantity obtained was so small, no further information is at present available, and further work will be undertaken with a view to determination of its identity, the results of which will be communicated later.

Esters.—In addition to the constituents enumerated above, small quantities of acetic and butyric acid esters were found to be present in the oil.

In conclusion I have to express my best thanks to Mr. A. R. Penfold, F.C.S., Economic Chemist, for much valuable advice and assistance during this investigation.

NOTES ON THE FOOD VALUE OF THE SNAPPER AND ON THE CONSTANTS OF WHALE OIL.

By W. M. DOHERTY, F.I.C., F.C.S.

[*Read before the Royal Society of N.S. Wales, November 1, 1922.*]

MUCH has been said of late in regard to the Pacific, and although these notes are not in the nature of elucidation of any problem, still the subject matters come essentially out of this ocean. They are no doubt of interest to those specially concerned, the first, indeed, perhaps of general interest since it sets down in exact terms the food value of a world famed food fish, to wit the snapper, which has not as far as I have been able to learn, yet been investigated from the point of view herein stated.

Some years ago, I undertook to fill in a conspicuous gap in food literature, namely to ascertain the food value of our fishes, and took as a beginning four of the most important local species, namely the sea mullet, black bream, sand whiting, and river garfish. I have lately supplemented this list by the fish mentioned. The specimen investigated was in prime condition and weighed 4 lbs. The portion analysed was taken from the side, close to the extremity of the dorsal fin. The muscular tissue was very firm and the flakes almost translucent. It was found to contain less fat than any of the others examined, the particulars of which I have set down in the following table for purposes of comparison:—

Fish	Weight in grammes.	Water loss at 100° C. per cent.	Total organic Nitrogen	Nitrogen from Gelatin	Nitrogen other than from Gelatin	Proteids equal Flesh-forming substances	Gelatin	Fat	Non-nitrogenous extract	Ash	Phosphoric Acid
Snapper (*Pagrosomus auratus*)	1800	78·82	3·25	0·49	2·76	17·46	2·69	0·33	1·56	1·38	0·58
Sea Mullet	1470	72·6	3·64	0·53	3·11	19·68	2·92	2·72	1·42	1·33	0·57
Black Bream	580	74·6	3·78	0·52	3·26	20·63	2·98	2·36	1·44	1·5	0·61
Sand Whiting	163	76·0	3·57	0·56	3·01	19·05	3·08	1·60	1·56	1·38	0·51
River Garfish	66	75·0	3·60	0·70	2·90	18·35	3·85	1·50	1·35	1·58	0·60

The nitrogen was determined by the Kjeldahl method. The comparative ease with which the substance was decomposed by sulphuric acid, suggested the thought that the preliminary action of the method might perhaps be an index or criterion of ease of digestion. In less than an hour from the time of beginning the experiment two grammes of the substance had been decomposed, a pale straw coloured liquid resulting.

The fat was extracted in a Soxhlet apparatus, the substance having been dried in a water oven in a bibulous paper thimble, was extracted with ether, and after subsequent pulverising was re-extracted. The small amount of fat found led to the use of a different process, namely a modification of that known as the Werner-Schmidt, in which the substance was decomposed by hydrochloric acid and the liberated fat collected by shaking out with ether. The result obtained confirmed that of the Soxhlet method. The extracted fat was dissolved in chloroform and the addition of strong sulphuric acid thereto gave a purple coloration. This reaction which it has been the custom to attribute to cholesterol or generally to bile pigments, is usually given with liver oils, though in my own experience I have frequently seen it produced from oils, other than liver oils.

The present significance of this colour reaction, according to recent investigations,[1] is that it has a direct connection with the growth promoting dietary factor known as Vitamine A. Whether this is so is a matter for further work, and it would be no doubt interesting if this our premier and much vaunted food fish did contain, besides the usual flesh-forming substances, such a powerful dietary primer as the elusive vitamine is conjured up to be.

Fish are popularly supposed to be superlative brain foods on account of a rich phosphorus content. This, however, is a fallacy, inasmuch as the quantity present in fish is about the same as that found in ordinary flesh-lean beef for instance.

* * * * *

My second note deals with whale oil.

A Scandinavian expedition visited the Pacific in 1912, and had its quarters in Jervis Bay. Its object was the exploitation of the southern seas for whales. I took the opportunity thus afforded of procuring samples of oil from the animals caught, keeping them distinct according to their species and the portions of the animal from which the oil was collected. The term whale oil, usually covers the product of all kinds of whale without distinction (with the exception of sperm oil which differs fundamentally from other kinds) and I was desirous of ascertaining if there were any marked differences in the constants of oils obtained from different sources. The object being to elucidate the matter for purposes of identification.

The following table shows the results obtained by me, the source of the oil being given in the first column:—

[1] "The Sulphuric Acid Reaction for Liver Oils," by Drummond and Watson, 'The Analyst,' August, 1922, p. 341.

Source of Oil.	Specific gravity at 15·5° C.	Refractive Index at 15·5° C.	Saponification Value	Acid Value.	Iodine Value.	Ester Value.
Blubber of Sei Whale	·9182	1·474	195	·75	99·6	194·2
Bones ,, ,,	·9186	1·471	197	1·25	86·4	195·7
Blubber of Humpback 1.	·9232	1·475	194·5	5·80	108·0	188·7
,, ,, 2.	·9212	1·476	192	1·00	119·0	191·0
Tongue ,,	·9212	1·473	199	2·2	105	196·8
Tongue of Blue Whale	·9197	1·4715	194	0·87	95	193·1
Stearim from Humpback	·9204	...	192	35·00	92	157
Oil and Spermaceti from head cavities of Sperm Whale.	·8779	1·463	145	12·7	66	132·3
Oil from blubber of Sperm Whale.	·8796	1·4667	127	3·0	89	124·5

The excessive acidities shown in the table are due to post mortem decomposition.

NOTES ON HORNBLENDE AND BYTOWNITE FROM HYPERSTHENE GABBRO, BLACK BLUFF, NEAR BROKEN HILL.

By IDA A. BROWN, B.Sc..
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(Communicated by W. R. BROWNE, D.Sc.)

[*Read before the Royal Society of N. S. Wales, December 6, 1922.*]

1. Introduction
2. Mineral Separation.
3. Hornblende
   (*a*) Chemical Composition.
   (*b*) Optical Properties.
4. Felspar
   (*a*) Chemical Composition.
   (*b*) Optical Properties.

Introduction.

The rock in which these minerals occur is the gabbro (A 186) from Black Bluff near Broken Hill, described in the Memoir of the Geological Survey of New South Wales, No. 8, 1922, App. 1, pp. 295, 353.

Under the microscope it is seen to be holocrystalline, medium-grained, with typical gabbroic fabric, and consists of plagioclase, light grey and colourless pyroxene (monoclinic and rhombic), and brown hornblende, with magnetite, apatite, and pyrites as accessories.

A Rosiwal analysis shows that the minerals are present in approximately the following proportions of percentage weights:—

Plagioclase	51·28
Pyroxene	35·51
Hornblende	11·43
Magnetite, etc.	1·81
	100·03

Mineral Separation.

The rock was crushed in a steel mortar and sorted by means of a set of sieves, those grains which were of the dimensions of the average grainsize of the rock, or slightly less than this, being chosen for separation. In this way apparently homogeneous grains of about the same size were obtained free from rock powder. These grains were partially separated by means of Klein's solution (cadmium borotungstate) of specific gravity about 2·85, when the separation of felspar from the rest of the rock was almost complete.

Apparatus—An ordinary Brögger funnel was found to be the most convenient apparatus to effect separation. Wide glass tubing was drawn out and fitted with rubber tubing and a pinch-tap, but was found to be unsatisfactory as a separating apparatus for several reasons. The converging sides of the tubing tend to cause congestion of the grains at the lower end, besides which the grains are apt to adhere to the rubber tubing. When this resistance is overcome the liquid drops suddenly and disturbs the equilibrium of the floating fraction. The apparatus can separate only a very small portion of the rock at a time.

A burette has the disadvantage of having too small an opening at the tap. The Brögger funnel, on the other hand, has a large opening and can separate a fair amount of material at one time, and yet is convenient to handle. Since it is made entirely of glass, with taps whose openings are of the same bore as the funnel itself, there is no tendency for the grains to stick in any particular portion. Another advantage is that the central tap can separate the two fractions without disturbing the equilibrium of the floating portion.

Heavy Liquids—Klein's solution proved to be a convenient liquid to use for the separation when the specific

gravity was not more than three. Above this density the liquid becomes too viscous, and it was found necessary to use Braun's solution (methylene iodide), which may be diluted with benzol (C_6H_6). If the methylene iodide becomes too opaque to use for the separation it may be decolourised by shaking with a few drops of a dilute solution of sodium carbonate and a few drops of a solution of sodium thiosulphate (hypo), then washing with distilled water and drying over calcium chloride. The chief disadvantage in using this liquid[1] is the rapid variation of the specific gravity with changes of temperature, which is 0·0022 for every degree centigrade at ordinary temperatures.

The liquid was poured into the Brögger funnel and the lower tap turned on slightly to allow the liquid to fill the tap. This prevents air bubbling through the solution and disturbing equilibrium when the tap is opened later. The grains of rock were then introduced, the stopper put into position and the funnel well shaken, with the central tap still open. It was found that the separation of the felspar from the hornblende and pyroxene was accomplished more effectively by holding the funnel in an oblique position, thus increasing the surface area of the liquid. The funnel was then gradually raised to the upright position, the grains in the lower fraction sliding along the glass towards the lower tap. The central tap was then closed and the lower fraction was run out. If the grains have not been allowed to stand long enough to become tightly packed, the lower fraction may be taken out with very little of the heavy liquid, so that the same solution can be used to separate a large quantity of rock.

The felspar in the upper fraction was allowed to accumulate for a number of separations, till finally most of the solution was run out, and the felspar was washed out,

[1] Johannsen, Manual of Petrographic Methods, p. 526.

cleaned with distilled water, and dried in an air oven at about 80° C. for two hours. This portion was crushed in an agate mortar and further cleaned by separation in the Brögger funnel with methylene iodide. It was then washed with benzol, dried, and examined with a lens before being ground for analysis.

The lower fraction from Klein's solution consisted of hornblende, diopside and hypersthene, the separation of which presented some little difficulty. Klein's solution at the density required for separation was too viscous, but the use of methylene iodide proved that the specific gravities of these minerals were so close that separation by heavy solutions was impossible. The electromagnet also failed to effect a separation. Eventually the hornblende was handpicked by scattering the lower fraction from the first separation in Klein's solution on a sheet of clean white paper and picking out the grains with a moist fine camel's-hair brush, with the aid of a large lens of low magnification, all composite grains being rejected. The hornblende was distinguished by its very dark colour and the fact that it was opaque in transmitted light. Also the cleavage of the hornblende was better developed than that of the pyroxene, with the result that the grains obtained were mostly cleavage pieces, the grains of pyroxene being more rounded. The hornblende was then carefully washed with distilled water and dried in an air oven at 80° C. It was left exposed to the air for several days before being used for analysis.

HORNBLENDE.

(a) *Chemical Composition.*

The hornblende obtained by the separation just described was analysed in duplicate, the mean of the two very concordant results being given in column I.

	I.	II.	III.	IV.	V.
Spec. Gravity	3·286*	...	3·218	3·283	3·226
SiO_2	44·27	738	45·00	41·67	39·95
Al_2O_3	9·56	93	9·41	11·38	17·58
Fe_2O_3	0·11	1	1·55	1·83	7·25
FeO	17·41	242	16·76	16·28	2·18
CaO	11·30	202	11·24	11·35	11·96
MgO	10·83	271	11·19	10·29	14·15
Na_2O	1·19	19	1·66	3·76	3·16
K_2O+	0·75	8	1·36	0·96	1·98
H_2O-	2·19	120	1·35	2·18	0·41
H_2O	0·04	..	..	...	·13
TiO_2	2·36	28	...	0·85	1·68
MnO	n. d.	...	0·33	...	tr.
F_2	...	...	...	...	·03
	100·01		99·85	100·55	100·46
$O=F_2$	...	...	...	...	·01
					100·45

* D_4^{16}

I. Hornblende from hypersthene gabbro, Broken Hill, N.S.W.

II. Molecular numbers for column I.

III. Black hornblende occurring with labradorite, Glen Bucket. Hintze, Handbuch der Mineralogie, II_2, (p) cxx, p. 1237.

IV. Black hornblende, Edenville, N.Y. Hintze, Handbuch der Mineralogie, II_2, (u) ccxxii, p. 1241.

V. Basaltic hornblende from Bilin, Bohemia. S. L. Penfield and F. C. Stanley, Amer. Jour. Sci., xxiii, 1907, p. 47.

From the analysis it may be seen that the mineral is a relatively rare type, the analyses given in columns (III) and (IV) being the only ones, out of several hundreds examined, which could be compared with it. For comparison, the analysis of typical basaltic hornblende is given in column V. The chief difference lies in the high percentage of ferrous oxide, with low ferric oxide and relatively low alumina, in the hornblende under consideration as compared with basaltic hornblende. The specific gravity of this hornblende like that from Edenville, is above the average, and the titania percentage is also high.

The chemical composition obtained from the analysis corresponds closely with the formula $Ca\ Fe_{12}\ Mg_{14}\ Al_{10}\ (Na, K, H)_{14}\ Si_{38}\ O_{124}$, with Ti replacing some Si.

As in certain sodic amphiboles like arfvedsonite,[1] the silica is insufficient to function as the only acid, and it seems probable that the acid-forming hydroxyl (OH) radical is present in the molecule, as suggested by Penfield and Stanley.[2]

The ratios of SiO_2 to the bases R'''_2O_3 and $R''O$, the latter including K_2O, Na_2O and H_2O, are as follows:

SiO_2	:	R'''_2O_3	:	$R''O$	SiO_2	:	$R''O$
766	:	094	:	862	1	:	1·11

The latter ratio, along with the high iron percentage, allies the mineral to the hornblende group of Penfield and Stanley, although the low alumina and high water connect it rather with the tremolite-actinolite group.

(b) *Optical Properties.*

Under the microscope the mineral is seen to occur as allotriomorphic grains which appear to be primary. It is translucent in thin section and has a brown colour. The cleavage is prismatic, the angle between the cleavage traces being 62°. There is also trace of a cross-fracture.

The pleochroism is intense, $X < Y < Z$

X = yellow

Y = light brown

Z = brown

Y is parallel to crystallographic "*b*" axis. $Z \wedge c = 21°$.

The mean refractive index was determined by the immersion of cleavage chips in a mixture of α-mono-clor-naphthalene and α-mono-brom-naphthalene. The refractive index of the liquid was measured on the Abbé refractometer and found to be about 1·66.

[1] Iddings, Rock Minerals, p. 349. [2] Amer. Jour. Sci., Series IV, 23, 1907, p. 30.

The extinction proved the symmetry of the mineral to be monoclinic. Simple twinning parallel to (010) was noticed in a few grains. The double refraction was indeterminate owing to the strong natural colour of the mineral. With convergent light the mineral gave a biaxial negative interference figure. The optic axial plane is parallel to (010). The value of the optic axial angle was calculated by the graphical methods of Prof. Becke, but the result is only an approximation as the brushes obtained were hazy, possibly owing to dispersion. The strong colour of the mineral also interferes with the measurement. 2V was calculated to be equal to 56°.

Little can be said of the relation between the chemical composition and the optical properties of this amphibole. In a paper[1] entitled 'A Contribution to the Optical Study of the Amphiboles,' W. E. Ford has worked on the minerals analysed by[2] Dr. F. C. Stanley and has drawn graphs showing the relations between the common oxides and the mean refractive index. Taking the mean refractive index to be 1·66 the hornblende under consideration agrees fairly well on the whole with these graphs, which show it to be a member between the tremolite-actinolite and hornblende groups. The following table shows the relation between the actual chemical analysis and the theoretical position on the graphs which have been drawn through the mean positions of the oxides for Dr. Stanley's analyses.

	I.	II.
SiO_2	44·27	46·0
Al_2O_3	9·56	8·5
Fe_2O_3	0·11	5·0
$Al_2O_3 + Fe_2O_3$	9·67	12·0
FeO	17·41	11·6
MgO	10·83	14·0
CaO	11·30	11·5
$K_2O + Na_2O$	1·94	3·0

[1] Amer. Journ. Sci., Vol. 37, 1914. [2] Amer. Jour. Sci., Vol. 23, 1907

I. Chemical analysis of hornblende, Broken Hill.

II. Calculated composition for hornblende with mean refractive index of 1·66. Amer. Jour. Sci, Vol. 37, 1914, pp. 183 – 186.

It will be noticed that the chief difference lies in the low percentage of ferric oxide and high percentage of ferrous oxide in the Broken Hill mineral. The axial angle also shows that the mineral is abnormal.

FELSPAR.

(a) *Chemical Composition.*

Since the felspar obtained by separation in heavy liquids was so clean, and the microscopic examination indicated that it was of constant chemical composition, it was considered worthy of further investigation. An analysis, carried out in duplicate, gave the following result:—

	I.	II.	III.	IV.
SiO_2	49·93	49·16	49·8	832
Al_2O_3	32·20	29·62	32·2	315
Fe_2O_3	abs.	1·15		
FeO	abs.			
CaO	15·22	15·31	15·0	271
MgO	abs.	0·91		
Na_2O	2·43	2·91	3·1	39
K_2O	0·50	0·70		5
H_2O	0·03	0·73		
	100·31	100·49	100·1	
Sp. Gravity	2·706*			

* $D_4^{13\frac{1}{2}}$

I. Felspar from Gabbro, Black Bluff, near Broken Hill.

II. Felspar from Diabase, Skye. (Hintze, Handbuch der Mineralogie II_2 (m) LXXVIII, p. 1528).

III. Calculated Chemical Composition of $Ab_{27}An_{73}$. Iddings.

IV. Molecular Nos. for column I.

The chemical analysis shows that the felspar is a remarkably pure member of the plagioclase group, which may be called bytownite, approximating to the composition Ab_{27} An_{73}.

(b) *Optical Properties.*

The mineral occurs as allotriomorphic grains, which show no trace of decomposition. Cleavage is well developed in two directions parallel to (010) and (001).

$$(001)\wedge(010) = 89°.$$

The mean refractive indices as measured by immersion of cleavage chips in liquids are

On (010) cleavage 1·571
On (001) cleavage 1·562

Zoning is absent. In sections perpendicular to (010) and (001) extinction is at 39° from the plane of the albite lamellæ and, in sections parallel to (010), at 28° from (001) cleavage.

Twinning is well developed after Carlsbad, albite and pericline laws, the last making an angle of 11° with (001) cleavage, on (010) section. The optic axial angle was determined by the graphical methods[1] of Professor Becke.

$$2V = 87°$$

In conclusion the writer wishes to thank sincerely Dr. W. R. Browne of the University of Sydney and Dr. C. Anderson of the Australian Museum, Sydney, for their kind help and advice during the preparation of this paper.

[1] Johannsen, Petrographical Methods, p. 480.

THE ECONOMIC UTILISATION OF THE RESIDUES FROM THE STEAM RECTIFICATION OF THE ESSENTIAL OIL OF EUCALYPTUS CNEORIFOLIA AND THE GERMICIDAL VALUES OF THE CRUDE OIL AND THE PURE 'ACTIVE' CONSTITUENTS.

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[*Read before the Royal Society of N.S. Wales. December 6, 1922.*]

IN Kangaroo Island, South Australia, large quantities of a narrow leaf Mallee, *Eucalyptus cneorifolia*, are distilled annually for its essential oil. It is the principal tree on the island from which eucalyptus oil for pharmaceutical use is obtained, and being of a rich reddish-brown colour with a most pronounced odour of the aromatic aldehydes requires rectification by steam distillation. This procedure results in the accumulation of fair quantities of a dark coloured residue, which is usually run to waste, and for which a use is desired.

On this account Mr. J. N. Hardwicke of the island mentioned, kindly furnished us with a gallon sample, and our results show that this waste product contains very valuable constituents that can be utilised commercially. The almost black, though mobile oil, was found to contain over 6% phenol (australol), and 25% aromatic aldehydes (principally cryptal), the remainder being sesquiterpenes, alcoholic bodies and polymerised constituents, as well as colloidal iron compounds derived from the stills. At

present it would not be a commercial proposition to separate the phenols and aldehydes, however interesting they may be from an academic standpoint, and it was thought that the simplest and most profitable method would be to convert the crude residual oil into a disinfectant. In this we think we have succeeded as the crude oil when emulsified with a neutral soap gives a co-efficient comparable to the tar oil products found on the market. There are also several eucalyptus oil disinfectant preparations on the market, but probably the active constituent in these is cineol. The Rideal-Walker value of cineol was determined by us (for comparison purposes) and a reference to the table will show that it has a value of 3·5. As a rule very few of these preparations contain much cineol, as they are usually compounded from eucalyptus oils high in terpenes, principally phellandrene, mixed with steam distillation residues consisting largely of sesquiterpenes and polymerised bodies.

Experimental.

The crude oil, although quite mobile was almost black in colour, and possessed a powerful odour of the aromatic aldehydes. It had a specific gravity $\frac{15}{15}$° C. 0·9811, and refractive index at 20° C. of 1·5046.

Phenol.—2000 c.c. were shaken repeatedly with 5% sodium hydroxide solution until all phenols were removed. On washing with ether, acidifying with dilute sulphuric acid solution, the liberated phenol was taken up with ether. After washing the latter with sodium bicarbonate solution and removal of the solvent 126 grams of crude phenol was obtained =6·3%. On distillation at 10 mm. it boiled at 115 −117° C., and on being allowed to stand overnight it solidified to a 'gel.' The crystals were pumped off and dried on a porous plate. On recrystallisation from xylene and sublimation they melted at 62 − 63° C. and gave a benzoyl

derivative melting at 72–73° C. The phenol is, therefore, australol.

The filtrate was repeatedly frozen until no more crystals were obtained. It gave a purple colouration with ferric chloride in alcoholic solution, but on distillation at 10 mm. it boiled at 115–116° C. and a careful examination of its chemical and physical characters showed it to be australol contaminated with a trace of a dextro-rotatory body. In the subsequent experiments dealing with germicidal values it is described as the 'liquid phenol.' The co-efficient shows in a striking manner the slight deviation from the pure solid australol in the lowering of the number due to the impurity.

Aldehydes.—1000 c.c. of the crude oil, after removal of phenol, was shaken with 1000 c.c. 33% sodium bisulphite solution, and after 24 hours the emulsion was filtered with suction. The solid crystalline cake obtained was washed with ether-alcohol until free from oil and dried on a porous plate. It weighed 120 grams and on treatment with sodium carbonate solution and steam distillation 48 c.cs. of aldehyde were obtained possessing the following characters:—Specific gravity $\frac{15}{15}$° C. 0·9792, optical rotation –7·6°, and refractive index, 20° C. 1·5271. On examination by the method described by one of us (A.R.P.)[1] it was found to consist approximately of 94% cuminic aldehyde with 6% phellandral. The aqueous bisulphite filtrate from the solid compound was separated from the oil and decomposed with sodium hydroxide solution when 180 c.c. crude cryptal was obtained. All three aldehydes were purified and gave similar constants to those described in the above mentioned paper, with the exception that the optical rotation of the cryptal was slightly lower, –68·2°.

[1] Journal of the Chemical Society, London, Vol. 121, (1922) p. 266–269.

In preparing the emulsions for determining the germicidal value of the different units 1% in 7% rosin soap solution was decided upon as being the most suitable for working purposes, particularly with regard to its commercial application. The soap solution alone was tested for an hour with the *Bacillus typhosus* culture and was found to have no germicidal properties. In arriving at this decision it is as well to bear in mind that two lines of investigation are available in this particular branch of research. Firstly, to find out whether the substances under examination have any germicidal value; secondly, to establish a value for those properties. The former is valueless from an economic standpoint unless the latter is obtained. Dr. Cuthbert Hall in his experiments on "Eucalytups oils, especially in relation to their bactericidal power" (1904), according to our conclusions, only dealt with the former. Dr. R. Greig Smith[1] in following on the work of the former used *Micrococcus aureus* and *Bac. coli communis* for determining the bactericidal powers of eucalyptus oils. A continuation of this work by the same author, Vol. 42, part 11, page 311, same Proceedings, entitled "The germicidal activity of the Eucalyptus oils," gave co-efficients to the various species of oil using *B. coli communis* as the test organism.

In all our experiments we used the standard organism *B. typhosus* as adopted by Ainslie Walker and known as the Rideal-Walker test for determining the germicidal value of disinfectants. *B. typhosus* is a more resistant type of organism than *B. coli communis* from an epidemiological point of view. The strain used was one that has been used for a number of years by the Department of Public Health, Sydney, for determining the Rideal-Walker values of hundreds of disinfectants submitted there. The suspensions of bacilli used were standardised 24 hours broth

[1] Proc. Linn. Soc. N.S.W., Vol. 44 (1919), part 1, p. 72.

cultures of the bacillus. All the active components of the crude oil were freshly prepared and tested within a day or two of their preparation.

Before submitting the results of the germicidal investigation it will be as well first to define the Rideal-Walker test:—The Rideal-Walker test is the adopted standard for determining the germicidal values of disinfectants, germicides and antiseptics. Stated briefly, measured quantities of a 24 hours broth culture of *B. typhosus* are exposed to measured quantities of the disinfectant to be tested, for definite periods against a standard strength of pure carbolic acid. Ainslie Walker adopted 1% as his standard. The mixed bacilli and disinfectant are then inoculated into tubes of sterile nutrient broth by means of a platinum loop at intervals of $2\frac{1}{2}$ minutes. The inoculated tubes are then incubated at 37° C. for from 24 to 48 hours and are then read. Tubes which show a turbidity (*i.e.*, growth) are marked with the plus sign, while those which remain clear (*i.e.*, no growth) are given the minus sign. Of course the action of the disinfectant is due to adsorption in a colloidal mixture, much the same as in the dyeing of fabrics, and the disinfectant can be exhausted by the addition of sufficient bacillary emulsion.

The first set of tests was made with aqueous suspensions of the different units. The aldehydic mixtures were fairly stable, but it was found to be impossible to arrive at any accuracy with regard to the amount of the aldehyde taken up by the water. After a number of trials about 0·5% was found to be the amount without any appreciable separation. The suspensions were opalescent in appearance, and as stated above, fairly stable, *i.e.*, there was no separation after a week. Similar difficulties were encountered with the phenols. The solid phenol remained unchanged in cold water, but on gently warming or placing

it in the incubator for an hour it liquified and a suspension could then be made. The phenol and crude oil suspensions were found to be less stable than those of the aldehydes. Small quantities gradually separated out after a day or two. Despite the difficulties encountered in making the aqueous suspensions their co-efficients were remarkably high as shown in the table (a) below:—

Table (a)—Aqueous Suspensions (approximate values only).

Carbolic acid ...	1
Crude oil	1·625
Cryptal (neutral) ...	12·5
Cuminal (neutral) ...	12·5
Phellandral (neutral)	4·5
"Liquid Phenol" ...	13
Solid Phenol ...	13

Ethyl alcohol was next tried as a solvent, but its co-efficiency had first to be determined. 32·5% of pure ethyl alcohol has a co-efficiency of 1, *i.e.*, equal to 1% carbolic acid.

Table (b)—1% units in 7% rosin soap (average results).

Carbolic Acid	2·833
Cryptal (practically) ...	12 (but decreased in fortnight or three weeks to under 7) and then remained constant at 5.
Cuminal...	12·75
Phellandral	9·25
"Liquid Phenol" ...	20·2
Australol (solid phenol)	
Cineol	3·5
Crude oil, 0·5% ...	9
Ditto 1% ...	7·57
Ditto 2·5% ...	7·5
Ditto 5·0% ...	6·5

1% cuminal in 10% ethyl alcohol gave a co-efficient of 12.

32·5% ethyl alcohol solution has a co-efficient of 0·031.

1% of crude oil freed from phenols and aldehydes plus 7% rosin soap has a co-efficient of ·05.

7% rosin soap has no co-efficient, *i.e.*, is non-germicidal.

The aldehydes, cuminal and phellandral when mixed with the rosin soap retained their co-efficiency, that is, did not lose their germicidal properties, although this is not the case with every aldehyde, cryptal being one of the obvious exceptions. When the phenol is incorporated with the soap it was found that the co-efficiency gradually increased. In the crude oil and soap mixture the co-efficiency increased with the dilution. The dilutions, however, must be made when the soap solution is added, otherwise no increase takes place. If the 5% is diluted to 0·5% the co-efficient would be 3·25(=6·5 to bring it up to unity) and not 9. [See Table (b)]

Investigations are in progress to determine the actual changes which take place in regard to this observation. An emulsion of the residual oil after removal of the active constituents was mixed with 7% soap solution and tested for any germicidal qualities. A reference to the table will show that this residue had a very slight value, probably due to traces of the active constituents.

Summary.—(1) The crude residual oil resulting from the steam distillation of the essential oil of *Eucalyptus cneorifolia* was found to have the following approximate composition,—Australol (phenol) 6·5%. Aromatic aldehydes. Cuminal and phellandral 5·0% (mostly cuminal). Cryptal 18·0%. Sesquiterpenes, sesquiterpene alcohols, and polymerised bodies, balance.

(2) The crude oil is shown to have a high germicidal value when suspensions are made in 7% neutral soap solution.

(3) The phenol and aldehydes are the active germicidal agents.

(4) The residue remaining after removal of these is practically non-germicidal.

(5) Neutral soap solution has no germicidal qualities when tested up to one hour.

(6) This waste product is thus shown to have, when suitably prepared, a practical commercial value, especially when compared with both coal-tar and the present eucalyptus oil disinfectants.

We desire to express our thanks to Mr. G. Hooper, Curator of the Technological Museum for kindly approving of our co-operation, and to Dr. E. W. Ferguson, Principal Microbiologist, Department of Public Health, Sydney, for kind permission to carry out the bacteriological work in the Microbiological Laboratory.

THE ESSENTIAL OIL OF ERIOSTEMON CROWEI (CROWEA SALIGNA) AND THE PRESENCE OF A NEW PHENOL ETHER.

PART I.

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Technological Museum, Sydney.

[*Read before the Royal Society of N. S. Wales, December 6, 1922.*]

THE botany of this plant was described by Baron von Mueller in "Plants of Victoria," 1, 119 (1860) and also in "Flora Australiensis," Vol. 1, page 329, under *Crowea saligna* (Andrew). It is an erect shrub growing to a height of approximately four feet with bright green glossy leaves and deep rose-pink flowers. It occurs fairly plentifully in the coastal districts of New South Wales, being usually found on the rocky slopes adjacent to creeks and rivers, and often close to the waters edge. The material for this investigation was collected at Middle Harbour where it is found in quantity in the particular habitat referred to. On crushing the leaves between the fingers a characteristic odour is evolved bearing a strong resemblance to safrol, which we believed to be the odoriferous constituent. It was not until the examination of the oil was in progress when endeavouring to separate the safrol that the higher boiling point of the principal fraction, 130 – 132° C. at 10 mm. (safrol boils at 109 – 110° C. at 10 mm.) showed it was not that phenol ether.

The Essential Oil.

The oils obtained from two consignments of leaves and terminal branchlets were of a bright yellow colour, heavier than water and highly refractive, with a characteristic

odour resembling safrol. The yield of oil was practically constant, 0·4%. The principal constituent was found to be a new phenol ether occurring to the extent of 90% for which we propose the name "Croweacin." It contains one methoxy group and in its general characters appears to be related to safrol. Its molecular formula is $C_{11}H_{12}O_3$ and so far as we are aware it has not hitherto been described. It is proposed to continue the investigation of this body and a paper dealing with its chemistry will be submitted at a later date. It was thought advisable to put on record its isolation, together with a note of its general chemical and physical characters at the earliest opportunity.

An interesting feature worth noting is that although the oil is optically inactive, on fractional distillation it is resolved into a mixture of the inactive phenol ether with both dextro and lævo-rotatory bodies, which together neutralise one another as regards optical activity.

Experimental.

Two lots of leaves and terminal branchlets, totalling 351½ lbs. collected at Middle Harbour, near Sydney, yielded on distillation with steam the following crude oils, possessing the chemical and physical characters, as shown in table:

Date	Weight of Leaves	Percentage Yield	Specific Gravity 15/15° C.	Optical Rotation	Refractive Index 20° C.
14/3/1922	118½ lbs.	0·4%	1·124	inactive	1·5321
29/8/1922	233 lbs.	0·4%	1·109	ditto	1·5302

Solubility in 80% alcohol by weight	Ester No. hot 1½ hours	Ester No. 1½ hours after acetylation	Percentage Methoxyl
5·5 vols.	7·5	7·5	13·73 (= about 90% $C_{11}H_{12}O_3$)
5·5 vols.	1·0	9·3	13·87 ditto

On distillation at 10 mm. the first lot of oil yielded 1% boiling below 128° C., and 98% between 128–133° C., whereas the second consignment gave 1% distilling below 65° C., 5% between 65–129° C., 82% at 129–132° C., and 10% between 132–140° C.

The physical characters of the last mentioned fractions are deemed worthy of publication as showing the difficulty in separating the phenol ether by fractional distillation in a condition of purity from the optically active bodies accompanying it:—

	Below 65°C.	65–129°C. at 10 mm.	129–131°C	131–132°C.	132–140°C.
Specific gravity $\frac{15}{15}$° C.	...	1·034	1·1024	1·1242	1·1248
Optical rotation	+27·8°	−0·55°	−1°	−0·15°	+0·4°
Refractive index 20°C.	1·4719	1·5182	1·5301	1·5318	1·5316

Determination of the Terpene.—The portion boiling below 65° C. at 10 mm. when mixed with a third of its volume of *l*-α-pinene $[\alpha]_D$ −50·18° readily gave a nitrosochloride, which on purification melted with decomposition at 109° C. It appears, therefore, to be d-α-pinene.

Lævorotatory constituent.—Repeated efforts to identify this body met with no success, particularly as only small quantities of the containing fractions were available.

Determination of the Phenol Ether.—Very little difficulty was experienced in separating by repeated fractional distillation at 10 mm. this constituent in a state of purity and in high yield from the first lot of oil distilled; on the other hand the return of pure material was very low from the second lot on account of the difficulty of freeing the ether from the accompanying lævo-rotatory and dextro-rotatory bodies, particularly as the latter was found to be a sesquiterpene with a closely related boiling point.

As thus obtained it is a pale tinted highly refracting liquid resembling safrol in general appearance, but with a slightly modified and less powerful odour. The two preparations possessed the following characters, viz:—

	No. 1.	No. 2.
Boiling point at 10 mm.	130–131° C.	130–132° C.
Ditto, ditto at 766 mm.	...	256–258° C. (u.c.)
Specific gravity $\frac{15}{15}$° C.	1·1339	1·1298
Optical rotation	inactive	inactive
Refractive index 20° C.	1·5330	1·5328

On placing in a freezing mixture at -20° C. it did not solidify, and was recovered unchanged after boiling for several hours with 100% (crystallisable) formic acid. No solid derivative from the addition of bromine at -20° C. in either dry ether or carbon tetrachloride solution could be obtained. The formula appears to be $C_{11}H_{12}O_3$ as indicated by the following combustion and molecular weight results, viz:—

(1) 0·1222 gm. gave 0·3086 gm. CO_2 and 0·0696 gm. H_2O
C=68·87%, H=6·33%

(2) 0·1354 gm. gave 0·3410 gm. CO_2 and 0·0755 gm. H_2O
C=68·68%, H=6·2%

(3) 0·1060 gm. gave 0·2674 gm. CO_2 and 0·0624 gm. H_2O
C=68·8%, H=6·54%

(4) 0·1271 gm. gave 0·3206 gm. CO_2 and 0·0756 gm. H_2O
C=68·8%, H=6·61%

$C_{11}H_{12}O_3$ requires C=68·75, H=6·25.

Molecular weight determinations.—(*a*) A molecular weight determination by the Landsberger boiling point method using acetone as solvent gave the following result: 1·0434 gram in 21 c.c. acetone elevated the boiling point 0·6° C. M. Wt. =184.

(*b*) A determination by the cryoscopic method using benzene resulted as follows:—0·3160 gram in 10 grams benzene lowered the freezing point 0·848° C. M.Wt.=186·3. $C_{11}H_{12}O_3$ requires 192.

Determination of Methoxy groups.—The percentage of methoxyl (OCH_3) obtained in two determinations by the method of Zeisel were 15·63% and 15·4% respectively. $C_{11}H_{12}O_3 : OCH_3 = 16·14\%$. Only one methoxy group is apparently present.

Oxidation with Potassium Permanganate.—The oxidation of the phenol ether by means of alkaline potassium permanganate solution at 0° C. appears to have taken a

somewhat different course to that usually experienced in the oxidation of other phenol ethers, such as safrol, elemicin etc., with which we have treated. Instead of obtaining a quantitative yield of either acid bodies, or aldehyde and corresponding acid, we separated a neutral body (not aldehydic) and a solid acid, the proportions of which vary according to the amount of oxidising agent used.

The combustion and molecular weight results of this neutral body point to the ether having taken up two hydroxyl groups to form a compound of the formula $C_{11}H_{14}O_5$ a reaction we cannot trace having seen recorded for a phenol ether before.

(*a*) 10 c.c. of the ether were shaken with 15 grams powdered potassium permanganate, 2 grams potassium hydroxide, 700 c.c. water and 700 grams ice, when the reaction was completed within five minutes. On removal of manganese sludge the liquid was concentrated to a small bulk and extracted with chloroform. On removal of the solvent a white crystalline body was obtained. It was recrystallised repeatedly from boiling ether (a solvent in which it is sparingly soluble in the cold) from which it separated in white nodular crystals melting at 93° C. (water bath), 95° (acid bath). It also crystallises at times in rosettes after the manner of eudesmol. It did not react with semicarbazide hydrochloride, and on combustion gave the following results:—

(1) 0·1242 gm. gave 0·2654 gm. CO_2 and 0·0681 gm. H_2O
C=58·28%, H=6·09%

(2) 0·1318 gm. gave 0·2828 gm. CO_2 and 0·0782 gm. H_2O
C=58·51%, H=6·58%

(3) 0·1026 gm. gave 0·2194 gm. CO_2 and 0·0584 gm. H_2O
C=58·32%, H=6·32%

$C_{11}H_{14}O_5$ requires C=58·4%, H=6·2%.

A molecular weight determination by the Landsberger boiling point method using acetone resulted in a value of 213 being obtained. $C_{11}H_{14}O_5$ requires 226.

The oxidation liquor after removal of the neutral body was evaporated to a smaller bulk, but only traces of acid bodies separated on addition of dilute sulphuric acid.

(*b*) On treating 10 c.c. of the ether with 30 grams powdered potassium permanganate, 4 grams potassium hydroxide, 700 c.c. water and 700 grams ice in a similar manner, besides the neutral body, several grams of a solid acid were separated. It crystallised from alcohol in brownish tinted rosettes and melted at 153° C.

On combustion it gave the following results :—

(1) 0·1002 gm. gave 0·2016 gm. CO_2 and 0·0396 gm. H_2O
C – 54·87%, H – 4·39%

(2) 0·1060 gm. gave 0·2130 gm. CO_2 and 0·0415 gm. H_2O
C – 54·80%, H – 4·34%

$C_9H_8O_5$ requires C = 55·10%, H = 4·08%.

Titration of 0·1944 gram in absolute alcohol with decinormal solution sodium hydroxide required 9·8 c.c. M.Wt. = 198. Theory requires 196.

The foregoing evidence points to the phenol ether possessing an allyl or propenyl side chain similar to other bodies like safrol, elemicin, etc., as an acid of this formula could only result from the 'splitting off' of such a chain from an ether of molecular formula $C_{11}H_{12}O_3$. As stated above, further work is being carried out and will be published as a Part II contribution.

Minor constituents.—A dextro-rotatory sesquiterpene was detected in the fractions boiling a little higher than the ether by the colour reactions which it gave with bromine vapour and sulphuric acid in acetic anhydride solution, which were identical with those given by similar constituents from other Australian essential oils. A paraffin of melting point 64 – 65° C. was also isolated from the high boiling residues.

This essential oil consists, therefore, of the phenol ether (90%), together with d-α-pinene, sesquiterpene, a paraffin, and an unidentified lævo-rotatory body.

THE RESINOUS EXUDATION OF ROSEWOOD, (*Dysoxylon Fraseranum*).

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[With Plates IX - X.]

[*Read before the Royal Society of N. S. Wales, December 6, 1922.*]

IN the present investigation, an examination was made of the timber of Rosewood, *Dysoxylon Fraseranum*, Bentham, (Natural Order Meliaceæ), to endeavour to trace the origin of the resinous exudation (so-called "sweating") which occurs in this species. Although the generic name is derived from words meaning "ill-smelling," this does not apply to this particular species; the vernacular name "Rosewood" indicating the rather pleasant odour of the seasoned timber. Rosewood was at one time much more extensively used as a cabinet wood than it is at present, but it is now practically discarded by furniture manufacturers, one of the principal reasons for this being the uncertainty of the permanency of the polish, which is often destroyed by the exudation. There is also some difficulty experienced in gluing up joints satisfactorily, on account of the oil present in the wood. Practically all the "Rosewood" furniture on the market to-day is made from stained Queensland Maple. The exudation is not uniform in its occurrence, since specimens of the timber in the Technological Museum, which have been polished for many years, show no signs of trouble. In one case, a specimen polished 25 years ago is still in good condition. Some french-polishers claim to have some method of treatment, which they state is efficacious. Others again say that it is impossible to guarantee the lasting qualities of the polish, and that

it is bound to "sweat" eventually. The presence of an oleo-resin in the timber is, of course, well known, and references are often met with as to its unsuitability for instrument or clock cases, on account of articles placed in them becoming sticky. In the present inquiry small boxes were made, and metal articles placed in them soon acquired the characteristic odour of the timber, indicating that the oil is decidedly volatile at ordinary temperatures.

A microscopical examination of a specimen of the reddish coloured heart-wood of the timber, which was felled in 1891 was made, but it was at first found difficult to prove the actual presence of an oleo-resin. No trace of resin passages was found, such as occur for example in many coniferous woods, and in the Dipterocarpeæ. In many of the vessels a dark brown deposit was found, but since this proved insoluble in the various solvents tried, it was hardly possible that it could cause the exudation. Sections treated with a dilute caustic potash solution, however, at once showed small round globules in certain of the cells, which, with a solution of alkannin in 50% alcohol gave the characteristic red colouration of resinous or oily bodies. A section was boiled in N. caustic potash for several minutes without affecting the contents of the vessels appreciably, but numerous rounded globules appeared in the cells of the xylem parenchyma (para- and metatracheal in this case) and also in the cells of the medullary rays. These globules were quite soluble in 100% alcohol. Sections boiled in water and then treated with alkannin also showed small globules, particularly in the elongated parenchymatous tissue. From the rapid rounding up of the oily contents of the cells into globules, when treated with caustic potash, even in the cold, it is probable that the oil is present in very minute droplets surrounding the walls of the cells. Caustic potash also has the effect of liberating a pinkish

colouration from the tissues of the heart-wood, and, as a rule, lightens the colour of the insoluble deposit in the vessels. Ferric chloride caused a darkening of the vessel contents, probably due to the presence of tannins, but little effect otherwise. The sap-wood which is pale in colour also showed numerous oil globules when treated with potash, both in the elongated parenchymatous cells and also in the medullary rays.

Rosewood felled in April, 1922, was also examined and gave practically similar results, as far as the distribution and behaviour of the oleo-resin is concerned, to those already outlined. The contents of the parenchymatous cells, which were somewhat granular in appearance, rounded up in 60% alcohol, the globules being slowly soluble in 70–80% alcohol, and finally went into solution in 90% alcohol. Caustic potash showed oil to be present also in the cells of the medullary rays. 100% alcohol reduced the colour of the vessel contents somewhat, but no solution occurred.

An examination was made of a small branch (about 45 mm. in diameter) of a tree of *D. Fraseranum*. Some of the vessels contained a light yellow transparent deposit, not always completely filling the pore in section, but quite insoluble in 100% alcohol or chloroform; no darkening was observed with ferric chloride. A 50% alcoholic solution of alkannin stained the contents slightly, but in many cases the deposit was unaffected, and subsequent treatment with 100% alcohol removed the colour, where stained. There was no diminution in volume, thus discounting the possibility of oil being present in the vessels. In older branches the deposit was darker in colour, and more granular in appearance, but quite insoluble in glacial acetic acid, petrol-ether, benzene, ether, chloroform or acetone. A few oil globules measuring about 0·0075 mm. in diameter, were found in the elongated parenchyma; these were stained bright red with alkannin and were soluble in 100% alcohol.

Whilst carrying out moisture determinations on Rosewood, a film of oil was noticed on the condensate which had been driven off in the form of steam from the wet timber. A quantity of shavings, 14 lbs., was subjected to steam distillation by the Economic Chemist for several days at a pressure of about 5 lbs. per sq. inch. The resulting oil was blue in colour, rather viscous, and had a specific gravity at 15° C. of 0·924. It possessed a rather unpleasant smoky smell, with little resemblance to the odour of the seasoned wood. The yield obtained was 2·7% on the wet weight, the moisture content being 41·87 on the dry weight. This is equivalent to a yield of 3·83% on anhydrous wood or 3·42% on air dried timber with a moisture content of 12%. After two days steaming, some of the shavings were examined microscopically and oil globules were found in shavings only 0·75 mm. in thickness, proving that, although readily volatile in steam, great difficulty is experienced in removing the oil from cells even slightly removed from the surface.

Since the "sweating" is evidently due to a volatile oleoresin, which is not entirely removed from cells less than 0·30 m.m., *i.e.*, $\frac{1}{80}$ inch from the surface, even after exposure to a temperature of over 100° C. for a period of several days, it seems reasonable to suppose that, if the timber is thoroughly seasoned, there should be little trouble experienced from further exudation, provided that the surface which is to be polished is not freshly cleaned off, but has been exposed to the air for some months at least, after final preparation. A small board, obtained from a log of Rosewood felled on 28th April, 1922, at Chillingham in the Tweed District, New South Wales, was divided into three, and the surfaces freshly cleaned up. One of them was steamed for 15 minutes, removing a brownish sediment and yielding an oil film on the surface of the condensed water.

The second was sponged with methylated spirits, becoming a little lighter in colour, and the third was not treated in any way. The three pieces were left for two months, and, after (1) and (2) had been lightly rubbed down, on account of the grain having lifted under the preliminary treatment, were french-polished. After some months the two treated portions are still in good condition, whereas the untreated piece already shows signs of the polish being destroyed.

Several pieces of Rosewood obtained from a log felled in April, 1922, were subjected to different conditions of heat and moisture in order to bring about the exudation, if possible. The moisture content of the wood when examined was 67·6% on the dry weight. One piece was placed for several hours in a temperature of 50° C. then exposed to 58° C. for six days and finally heated to 100° C. for 4 hours, with no evidence of any exudation. A similar piece of wood was exposed to an atmosphere saturated with water vapour at 58° C. for 24 hours then alternating moist and dry air at the same temperature for 7 days, but again no sign of sweating was observed. A fresh surface was then put on the timber, and it was exposed intermittently to a temperature of 58° C. for three months, but there was still no trace of "sweating," although the Rosewood odour was still quite pronounced. A third piece was planed up and allowed to season at air temperature, but, after 4½ months there is no external evidence of any oleo-resin, though a section showed that there was no lack of oil globules in the woody tissues. A piece of Rosewood from a log felled about 1910 showed very marked evidence of "sweating," there being numerous small oily patches on the surface. It was freshly planed up and exposed to a temperature of 58°C. intermittently for three months without any exudation appearing. On heating for several hours to 100° C., how-

ever, several small oily spots were seen on end section, otherwise the wood was free from stain.

Pieces of Rosewood of various ages after felling were placed under the receiver of a vacuum pump, and the pressure reduced to a few inches of mercury. There was, however, no alteration in the appearance of the timber.

An examination was also made of the heart-wood of *Dysoxylon Muelleri*, Red Bean, and *D. Pettigrewanum*, Satin-wood, and although it was proved that a small quantity of oleo-resin was present, no evidence has been found, as far as the former timber is concerned, that any sweating occurs. Both timbers are also, when seasoned, almost devoid of smell.

A transverse section of the wood of *D. Fraseranum* (Fig. 1) shows it to be a diffuse porous type. The vessels are comparatively large, measuring up to 0·18 m.m. in diameter, and are often solitary or grouped into rows of up to about five. In many of them is the characteristic dark brown insoluble deposit found in this timber. At right angles to the medullary rays are numerous bands of thick walled wood fibres, alternating with irregular zones of metatracheal xylem parenchyma. Figure 2 shows a more highly magnified transverse section than the preceding one. The deposit in the vessels is amorphous and often irregularly cracked. About the middle of the field and towards the bottom are two bands of the oil bearing parenchymatous tissue. The cells are rather thick walled, and the walls, particularly the end ones, bear numerous oval or round simple pits.

Figure 3 shows a longitudinal tangential section of the heart-wood. The irregular nature of the insoluble deposit in the vessels is typical. The medullary rays are usually multiseriate, consisting of two rows of cells. The wood

fibres are commonly septate with very thin dividing partitions, and are often saw-edged at the ends. Scattered throughout the tissues are the rows of elongated xylem parenchyma in which the oleo-resin also occurs, the cells measuring up to 0·1 m.m. in length, and 0·04 m.m. in diameter. In radial section (Figure 4) the medullary rays are found to be homogeneous.

Summary.—A resinous exudation commonly known as "sweating" occurs in the timber of Rosewood, *Dysoxylon Fraseranum* destroying the polish.

A microscopical examination showed the presence of small oil globules in certain cells of the woody tissues, *e.g.*, the elongated xylem parenchyma and also in the medullary rays, not only in mature heart-wood, but also in the sap-wood of young branches.

Steam distillation of shavings gave a bluish coloured, rather unpleasant smelling, viscous oil, with a yield of 3·4 % on air dry wood.

Attempts to cause "sweating" to take place by subjecting the timber to varying conditions of heat and moisture were as a rule not successful.

Pieces of Rosewood steamed or sponged with alcohol apparently retain the polish much longer than untreated wood.

Sweating is probably due, in many cases, to the use of unseasoned timber, or to the polishing of wood which has recently been given a fresh surface, *i.e.*, oxidation of the oleo-resin in the surface cells has not taken place.

In conclusion I wish to thank Prof. A. A. Lawson, D.Sc., and Mr. G. Hooper, F.T.C., for the interest and helpful criticism given in this work. I am also indebted to Mr.

J. H. Maiden, I.S.O., F.R.S., Botanic Gardens, Sydney, for some of the material worked upon, and to Mr. H. E. Cooper of Murwillumbah, N.S.W., for his kindness in sending specimens of recently felled Rosewood.

EXPLANATION OF PLATES.

PLATE IX.

Fig. 1. Transverse section of heart-wood of *Dysoxylon Fraseranum*. × 30.

Fig. 2. Transverse section of heart-wood of *Dysoxylon Fraseranum*. × 100.

PLATE X.

Fig. 3. Longitudinal tangential section of heart-wood of *Dysoxylon Fraseranum*. × 30.

Fig. 4. Longitudinal radial section of heart-wood of *Dysoxylon Fraseranum*. × 30.

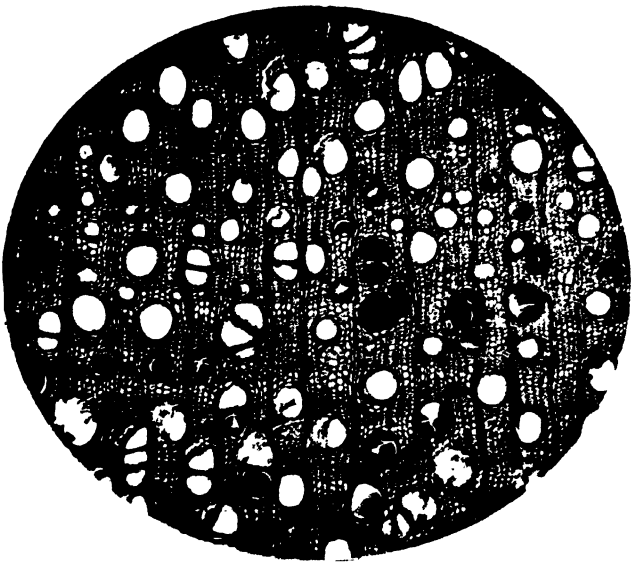


Fig. 1

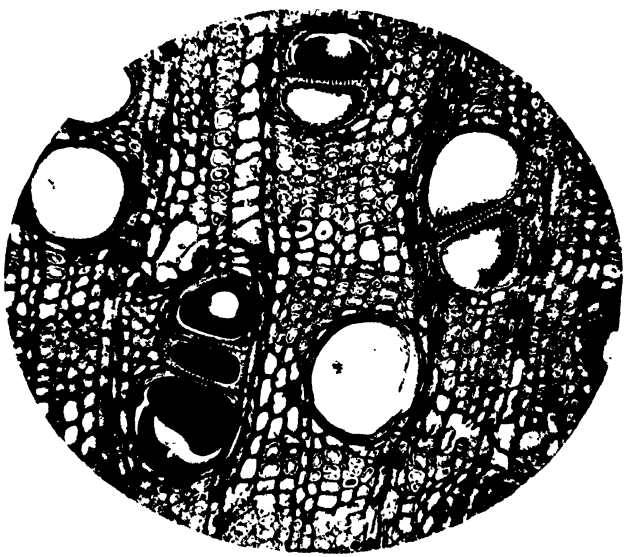


Fig. 2.



Fig. 3.

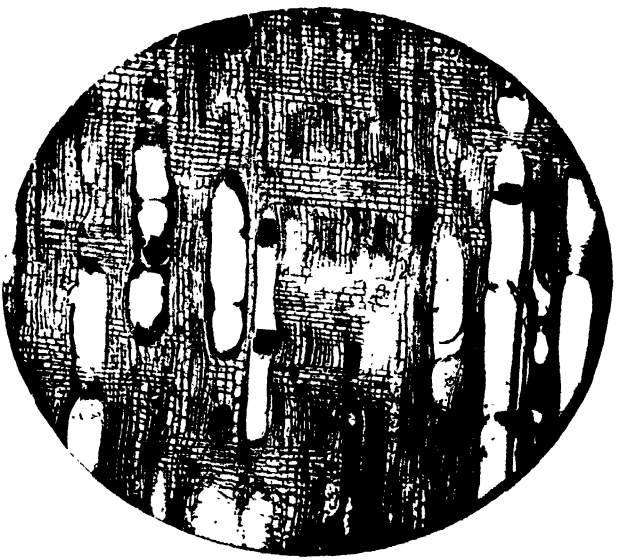


Fig. 4

A METHOD OF IDENTIFICATION OF SOME HARDWOODS.

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[*Read before the Royal Society of N. S. Wales, December 6, 1922.*]

THE Eucalyptus timbers which are by far the most important group of the Australian hardwoods, are, in many cases, extremely difficult to determine with accuracy. Although there is little in common between the open grained Mountain Ash type such as *Eucalyptus Delegatensis*, and the close grained "Boxes," *e.g. E. hemiphloia*, yet certain of these timbers fall into groups, which possessing similar texture, colour and weight, are very difficult to separate. Again, though a timber such as Blackbutt, *E. pilularis*, is usually distinct from Spotted Gum, *E. maculata*, at times these timbers resemble each other to such an extent that it is impossible to classify them with certainty, without information as to the nature of the bark or other morphological characters. Similarly the Sydney Blue Gum, *E. saligna* is very difficult to separate, at times, from the Mahogany, *E. resinifera*, or Jarrah, *E. marginata*. Colour of the timber is liable to vary within limits, even in the one log, and this variation is sufficient to make any very exact colour classification impossible. The specific gravity of any one timber is by no means a constant, and may vary ten pounds per cubic foot or even more in the one species, being dependent on the conditions of growth. Although some woods are much lighter than others, yet, when the difference in average weight is not marked, this variation renders too critical a comparison, based on weight, of little

value for diagnostic purposes. The 'closeness' or 'openness' of the grain, *i.e.*, the relative size of the vessels or 'pores' is probably one of the most valuable aids to classification, but here again variation occurs, within limits, in the same timber, evidently due to different rates of growth of the tree, slow growth usually producing a closer grained timber and *vice versa*.

On account of the difficulties in exact determination as pointed out above, it would be of great value if some more definite method could be obtained, which while simple in application, would nevertheless, give a clear indication as to the nature of the timber.

References are often met with in literature dealing with this subject, to the fact that extracts prepared from the timber may possess some value for diagnosis, and the object of this investigation was to determine whether such methods would be of value in the case of certain of our hardwoods. Fortunately, on account of the very large collection of timber specimens in the Technological Museum it was possible to obtain samples for comparison from different localities, and moreover, what is most important, the botanical names are based on herbarium material obtained from the same tree. There is thus practically no possibility of error in the scientific nomenclature, a point which cannot be overstressed in any work dealing with timbers.

The method adopted was to boil 0·5 g. of shavings in 25 c.c. of water for one minute and filter off the extract, which was diluted with a further 25 c.c. of water. This liquid was further diluted, if necessary, to give a colouration best suited for comparison when additions were made of solutions of ferric chloride, caustic potash, or lime water. Stannous chloride, potassium bichromate, copper sulphate, ferrous sulphate, etc., were also tried, but the first-men-

tioned reagents were found to be most satisfactory. Since the whole method is essentially one of comparison, the exact details are unimportant provided the same conditions as to quantities and concentrations are applied throughout. Care was taken that the shavings did not include any kinoid material from the 'gum-veins' which are very numerous in certain Eucalypts.

In comparing three pale coloured timbers, which are often sold under the name of Mountain Ash or Tasmanian Oak, *e.g.*, *E. Delegatensis*, the Southern Mountain Ash of New South Wales, and the Gum-topped Stringybark of Victoria; *E. obliqua*, Messmate or Stringybark, and *E. regnans*, the Giant Gum, it was found that, as a general rule *E. regnans* gave a much lighter colouration with ferric chloride than *E. Delegatensis*. The latter timber also gave a darker colour with caustic potash than *E. regnans*. *E. obliqua* gave, in the specimens examined, a darker colouration, more blue-black in colour, with ferric chloride than either of the other two species.

Turning now to a group of timbers which are at times difficult to separate, such as *E. microcorys*, Tallow-wood; *E. maculata*, Spotted Gum; and *E. pilularis*, Blackbutt; it was found that *E. maculata* gave practically no colouration with ferric chloride, whereas the other two gave a very decided reaction. The extract in the case of *E. maculata* was clear, the others were inclined to become turbid. The difference between *E. microcorys* and *E. pilularis* was not so marked, but with the addition of lime water to the diluted extract, it was found that *E. microcorys* gave a pink colour whilst *E. pilularis* was more brownish.

Comparing three fairly open-grained, red-coloured Eucalypts between which there is liable to be confusion, *E. resinifera*, Mahogany; *E. saligna*, Sydney Blue Gum; and *E. marginata*, Jarrah; it was found that *E. resinifera* gave

a much darker reddish-brown extract than either of the other two. *E. saligna* gave a yellowish to yellow-brown extract, whilst that from *E. marginata* was practically colourless. With ferric chloride *E. resinifera* gave a greenish colouration, *E. saligna* blue and *E. marginata* only a very slight indication. Caustic potash gave a pink colour with *E. resinifera*, more reddish-brown in the case of *E. saligna*, and a yellowish tint with *E. marginata*. Lime water also gave a pink with *E. resinifera*, more brown in the case of *E. saligna* and no alteration with *E. marginata*. Other red timbered Eucalypts with a comparatively open grain, such as Bangalay, *E. botryoides*; Swamp Mahogany, *E. robusta*; Flooded Gum, *E. saligna* var. *pallidivalvis*; were also examined, but no very conclusive results were obtained. Specimens of *E. robusta* and *E. botryoides* were found to be somewhat variable in the behaviour of the extracts, and although some samples of *E. robusta* were almost identical with *E. botryoides*, in other cases the results were dissimilar.

Among the closer grained red-coloured Eucalypts, *e.g.*, *E. tereticornis*, Red Gum; *E. crebra*, Narrow Leaved Ironbark; *E. punctata*, Grey Gum; *E. rostrata*, Murray Red Gum; *E. tereticornis* was found to be exceptionally variable. With ferric chloride the colour of the extract ranged from deep blue to almost colourless. In comparing the two 'Red Gums' *E. rostrata* and *E. tereticornis* it was found difficult to separate them with certainty, though *E. rostrata* gave more uniform results and lighter colourations than the exceptionally dark *E. tereticornis*. In the specimens examined *E. rostrata* gave fairly close results to those obtained for *E. crebra*. Other timbers tested such as *E. Dawsoni*, Slaty Gum; *E. polyanthemos*, Red Box; *E. longifolia*, Woollybutt; and *E. propinqua*, Small-Fruited Grey Gum; did not give conclusive results. Specimens of

the two Grey Gums, *E. propinqua* and *E. punctata*, indicated that *E. propinqua* gave a darker coloured extract than *E. punctata*, and correspondingly darker colourations with ferric chloride, lime water, etc.

Comparing the darker coloured Ironbarks, *e.g.*, *E. crebra*; *E. siderophloia*, Broad Leaved Ironbark; and *E. sideroxylon*, Red Flowering Ironbark; it was found that *E. crebra* gave a lighter colouration with ferric chloride which was greenish in colour, whereas the other two species gave a more bluish tint. Lime water and caustic potash did not give a decided difference. It is interesting to note that burning the shavings of these timbers does not show any marked variation, though *E. crebra* was found to smoulder slightly, whereas the others 'burnt black.'

Light coloured timbers of the Stringybark group, *e.g.*, *E. eugenioides*, White Stringybark; *E. capitellata*, Brown Stringybark; *E. acmenioides*, White Mahogany; and *E. lævopinea*, Silver-topped Stringybark; showed that *E. acmenioides* gave a much lighter coloured extract than the others. With ferric chloride, *E. lævopinea* gave very dark blue colourations. The others also gave blue, but without sufficient contrast to separate them. Both caustic potash and lime water showed a more decided pink colour with *E. acmenioides* than with remainder, *E. lævopinea* giving darker colourations throughout. It was not found possible to separate *E. eugenioides* from *E. capitellata* with any certainty, though the latter timber was inclined to give darker tints than those obtained from *E. eugenioides*.

Apart from the Eucalypts are numerous other timbers which fall into groups which are difficult to separate at times. Thus *Tristania conferta*, Brush Box; and *Syncarpia laurifolia*, Turpentine; are two timbers which sometimes resemble each other closely. It was found that the Turpentine gave a much darker colouration with ferric chloride

or caustic potash than the Brush-Box, and little trouble was experienced in separating them. Another test is by burning the shavings, since the Turpentine goes out as soon as the flame dies down, whereas the Brush Box smoulders to a grey ash.

It was thought probable that the age of the specimens, *i.e.*, the time elapsed since felling might affect the colour reactions to some extent. In the case of *E. tereticornis*, the timber giving a marked colour with ferric chloride was obtained in 1916, whereas the specimen giving practically no colouration was felled in 1907, the two localities being widely different. On the other hand, *E. propinqua* obtained in 1895 gave a darker colouration with ferric chloride than timber felled in 1910. Again, a specimen of *E. robusta* giving a dark extract was obtained in 1913, whilst a specimen from a tree felled in 1916 gave a much lighter colouration. The conclusion arrived at in regard to age after felling is, that it has no definite general effect in any one direction, although it may possibly affect the behaviour of any one species.

Comparing the sizes of the trees and therefore the ages, assuming the rates of growth to be approximately equal, it was found that, whereas the more recent specimens of *E. robusta* which gave the lighter colourations were obtained from a log three feet in diameter, the darker colours were from a log only 16 inches in diameter. On the other hand, in the case of *E. propinqua*, the darker colour reactions were obtained from a log three feet in diameter. It is evident from these two cases that the size or age of the tree has apparently little effect.

To compare the timber of different periods of growth in the same tree, extracts were prepared from near the heart, and also from near the sap-wood of *E. tereticornis*, in both

cases of course heart-wood being used. The heart-wood was darker than the sap-wood, but the extract was somewhat lighter in colour, and the reactions showed a corresponding variation. It seems evident, therefore, that some lack of uniformity, as far as depth of colour is concerned, may occur in different sections of the heart-wood of one log.

It is evident that the colour of the timber is no criterion of the colour of the extract. Very often a light coloured timber will give a much darker extract than one which is dark red in colour. Thus *E. paniculata*, White or Grey Ironbark, gave a dark brown extract, whereas that obtained from a Red Ironbark such as *E. crebra*, was almost without colour.

Since any reference to colour can only be more or less vague without comparison with a recognised colour standard, no stress has been put upon the description of such colourations. It is for many reasons essential that an actual comparison be made at the same time, and with the same conditions, between the doubtful specimen and those timbers which it most nearly resembles. On account of the variation which has been shown to exist in the extracts of different specimens of the same species, it is impossible to do more than indicate how this method can be applied. It is clearly impossible at this stage, at any rate, to attempt any key to identification based on such colour reactions. Where applicable, however, this method has the great advantage that it enables one to work with small samples which are often submitted for identification, and which are difficult to compare on account of their size. It is also quick, and much easier to apply than a microscopic examination necessitating sections, which are almost impossible to prepare satisfactorily except by an experienced worker.

Summary.—In order to ascertain whether an accurate method of identification of certain hardwoods could be

devised, particularly the Eucalypts, some of which closely resemble each other in colour, weight and texture, an examination was made of an extract obtained by boiling a definite weight of shavings in a known volume of water. The tests carried out on the Eucalypts show that it is impossible to generalise or to prepare any key to identification along these lines. The method must be used with caution on account of the variation in behaviour found in the same timber. It is of value in many cases, however, and without doubt is more accurate in these species than any ordinary superficial examination. It is only safe to use this method by actual comparison of the extract from the doubtful specimen, with extracts similarly prepared from authentic specimens of the woods with which the comparison is being made.

I am indebted to Prof. A. A. Lawson, D.Sc., for his kindly criticism in this work.

NOTES ON THE OCCURRENCE OF GASTRIOCERAS AT THE IRWIN RIVER COAL-FIELD, W.A.

AND A COMPARISON WITH THE SO-CALLED PARALEGOCERAS FROM LETTI, DUTCH EAST INDIES.

By W. S. Dun and Prof. Sir Edgeworth David, K.B.E., C.M.G., D.S.O., D.Sc., F.R.S.

[With Plates XI – XIII and Text Figures.]

[*Read before the Royal Society of N. S. Wales, December 6, 1922.*]

The late R. Etheridge Jnr. described a large ammonoid[1] found by the Geological Survey of West Australia in the Irwin River Coal-field, under the name of *Gastrioceras Jacksoni*, in the year 1907.

In a recent examination of the Irwin River Coal-field by Dr. W. G. Woolnough, and a still later reconnaissance by Mr. A. Gibb Maitland and Professor David in the same area, it was ascertained that the horizon for *Gastrioceras* as estimated by Dr. Woolnough was some 1600 feet above the basal tillites of the field, and over 5000 feet below the horizon of the Irwin River Coal Measures. Diamond drill bores last year proved that marine strata with numerous *Aviculopecten* etc. overlie these coal measures and are therefore probably the equivalent of the Upper Marine series of the Hunter River district. The Irwin coal measures in this case become the probable equivalents of the Greta Coal Measures of New South Wales. Hence the horizon for *Gastrioceras* is far down in the equivalent of the Lower Marine series of the Hunter River district. It is therefore a matter of great stratigraphical importance to determine the approximate horizon of this *Gastrioceras* of the Irwin Coal-field in reference to its place in the Tethyan fauna of the Dutch East Indies; and as the

[1] Bull. Geol. Surv. W. Austr., No. 27, p. 36, pl. 9, f. 1 – 3.

approximate age of these Malay Archipelago strata is known, as tested by Northern Hemisphere standards of geological chronology, such a determination will help considerably to the more accurate placing in geological time of the Lower Marine series of Eastern Australia.

At the Irwin River Coal-field the *Gastrioceras* occurs in extraordinary numbers, the individual specimens almost touch one another, and form a bed of clayey limestone only about 6 inches in thickness. Stratigraphically therefore it is a remarkably useful horizon for field mapping. Already Dr. Woolnough has traced these beds in the field for a distance of over 20 miles.

The largest specimen collected is fragmentary, but is portion of the last whorl 6·2 inches in width, 3·25 in depth and indicates a diameter of about 12·5 inches for the complete individual.

While some considerable time may be needed in order to elaborate the taxonomy of these forms (obviously a very important work as geological classification depends so much on higher forms like the Cephalopods) we think it of importance at once to place on record the fact of the great similarity, if not the absolute identity of *Gastrioceras Jacksoni*, Etheridge, from the Irwin River Coal-field, and *Paralegoceras sundaicum*, Haniel, from the Island of Letti.[1]

For comparison of these forms we publish two suture lines, (figs. 2, 3), of *Gastrioceras Jacksoni*, and (fig. 1) the repro-

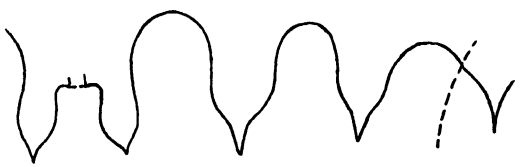
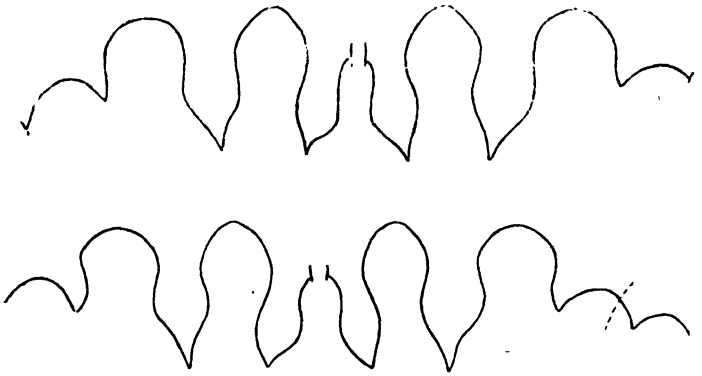


Fig. 1. Suture line of *Paralegoceras sundaicum*, Haniel, *op. cit.*, p. 164.

[1] Jaar. van het Mijn. in Nederland Oost-Indie, 1914, Part 1, pp. 163–165, pl. xvii.



Figs. 2 and 3. Suture lines of *Gastrioceras Jacksoni.*

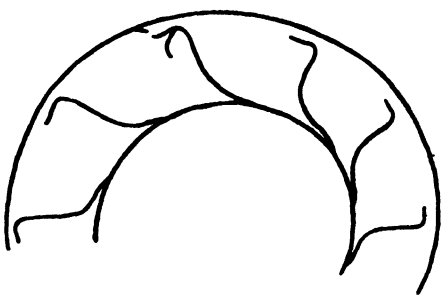


Fig. 4. Portion of fifth whorl of *Gastrioceras Jacksoni* showing the sphonal collars.
[Collected by Dr. W. G. Woolnough].

duction of Dr. Haniel's delineation of the suture line of his *Paralegoceras sundaicum.* At Letti the *Paralegoceras* is stated to be associated with *Agathiceras sundaicum* related to *A. Suessi* from the Sosio limestone of Sicily and *A. uralicum*, Karpinsky, in the Artinsk formation, as well as *A. cisconense*, Smith, from the upper coal measures of Texas. It may be added that *A. micromphalum* is not uncommon both in the Upper and Lower Marine beds of the Hunter and Illawarra coal fields, being specially abundant in the Lower Marine series.

At Letti *Paralegoceras* is also associated with *Propinacoceras*, the latter being usually considered to be of Lower Permian Age.

The following Brachiopods are also associated at Letti with the ammonoids:—

Productus cora, d'Orb.
Productus spiralis, Waagen
Chonetes strophopmenoides, Waagen
Spirifer rajah, Salter
Spirifer (Reticularia) lineatus, Martin
Martinia nucula, Rothpletz
Retzia radialis, Phill., (var. *grandicosta*, Dav.)
Notothyris
Dielasma

The present opinion of the geologists of the Dutch East Indies is that the strata containing the above fossils are of Permian, mostly Lower Permian, age and that they are stratigraphically superior in position to the Upper Carboniferous *Fusulina* limestones of the same region.

EXPLANATION OF PLATES.

Plate XI.

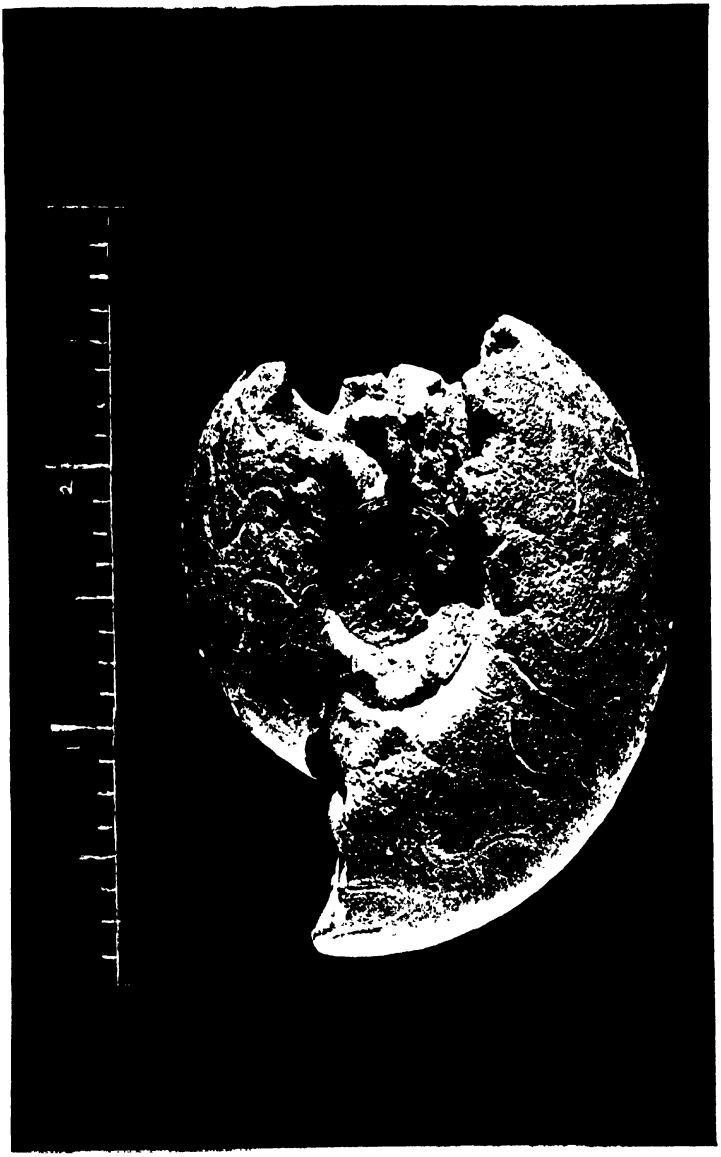
Gastrioceras Jacksoni, Eth. fil. Specimen showing umbilical region and form of lateral lobes and saddles.

Plate XII.

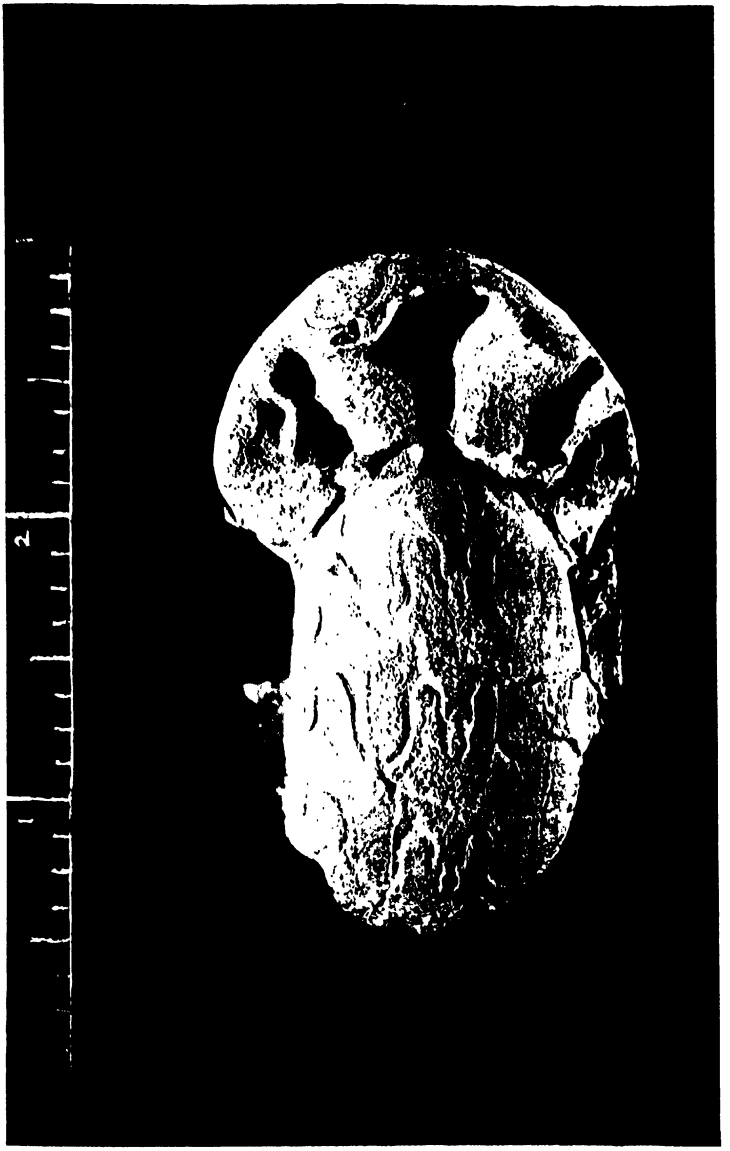
Gastrioceras Jacksoni, Eth. fil. Specimen shown in Plate XI. Showing suture line and general appearance of septal surface. (See text figures 2 and 3).

Plate XIII.

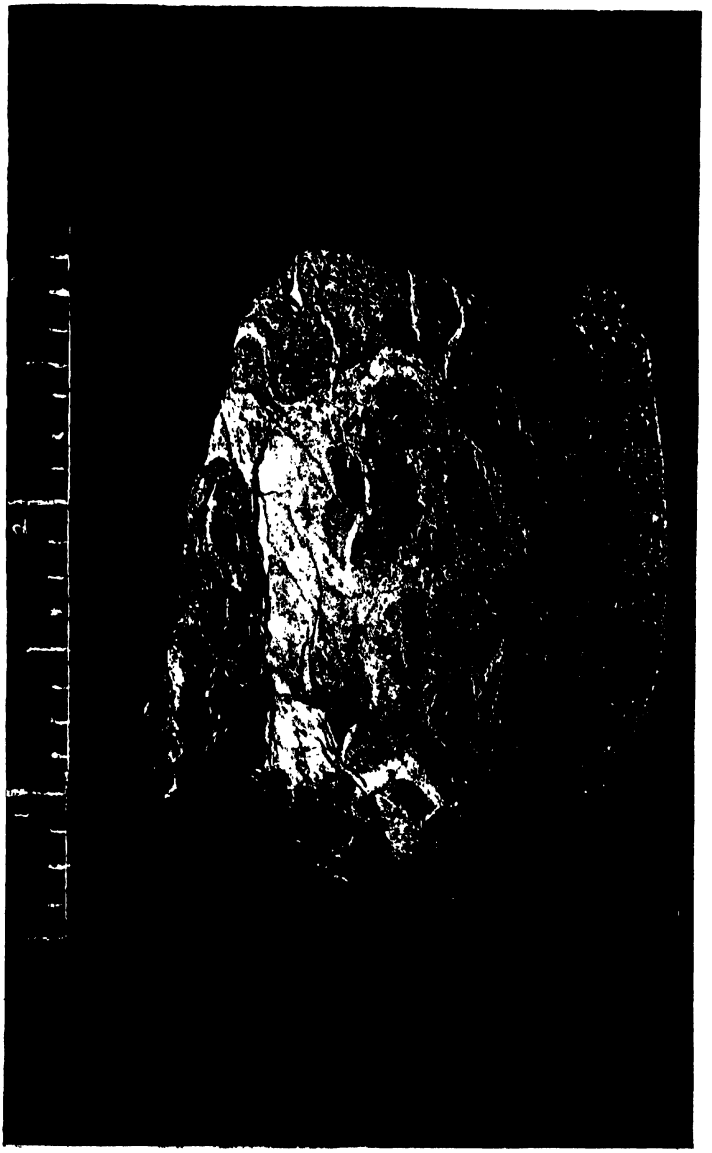
Gastrioceras Jacksoni, Eth. fil. Ventral aspect of large individual showing suture lines.



Gastrioceras (?) Jacksoni, Nat. Size.



Gastrioceras (?) Jacksoni, Nat Size



Gastrioceras (?) Jacksoni, Nat Size.

THE GLUCOSIDE OCCURRING IN THE TIMBER OF THE "RED ASH," ALPHITONIA EXCELSA, REISS.

By HENRY GEORGE SMITH and JOHN READ.

[*Read before the Royal Society of N. S. Wales, December 6, 1922.*]

THE "Red Ash," *Alphitonia excelsa*, Reiss, belonging to the N.O. Rhamneæ, is widely distributed throughout the eastern and northern parts of Australia, and in Queensland it is one of the characteristic trees of the "Brigalow scrubs." It produces a timber of excellent quality, and as a hardwood is suitable for coach-building, heavy doors, and similar uses.

The heart-wood of this timber, when freshly cut, is of a light pinkish tint, but on exposure to light and air it darkens considerably, eventually assuming a deep red colour, whence the common name of "Red Ash." This distinguishing colour, however, exists only on the surface, as on removing a thin shaving the wood beneath is shown to be of a much lighter tint. The red colour is caused by the slow alteration or oxidation of a characteristic constituent, which in certain instances is deposited in some quantity in the shakes and cracks of the timber.

The material used in the present investigation was obtained from the Sydney Technological Museum, which recently came into possession of a log of "Red Ash" collected near Morrisett, New South Wales; the heart-wood of this specimen was much shaken, and the shakes contained a soft white substance, somewhat chalky in appearance, which was evidently an aggregation of the characteristic constituent always present in the timber of this tree.

In its general physical and chemical behaviour, this secretion of *Alphitonia excelsa* shows a marked resemblance to fustin, a glucoside of fisetin, melting at 218–219°, which was first isolated from the wood of young fustic, *Rhus cotinus*, L., by Schmid (Ber., 1886, *19*, 1734). Fisetin itself, the yellow colouring matter of young fustic, had been extracted and characterised many years previously by Chevreul, who called it "fustin" (Leçons de Chimie appliquées à la teinture, A. II, p. 150). Later, fisetin was shown by A. G. Perkin (Trans. Chem. Soc., 1897, *71*, 1194) to occur in the wood of *Rhodosphacra rodanthema*, Engl. —the yellow cedar of New South Wales—both in the free state and in the form of a supposed glucoside, melting at 215–217°, and corresponding to the formula $C_{36}H_{30}O_{16}$. Owing to its unusual resistance to hydrolysis, the complete diagnosis of this substance has been attended with considerable difficulty, and some doubt still exists concerning the identity of the substance from *Rhodosphacra rodanthema*, melting at 215–217°, with the fustin from *Rhus cotinus*, melting at 218–219°. Perkin (*loc. cit.*, p. 1197) originally considered the substances to be probably distinct, but more recently mention has been made of the possibility of their identity (Perkin and Everest, The Natural Organic Colouring Matters, 1918, p. 186).

It was surmised by Schmid that fustin yielded rhamnose on hydrolysis, and Perkin accordingly suggested the formula $C_{36}H_{26}O_{14}$ for this substance, the hydrolysis being thus represented by the following equation:—

$$C_{36}H_{26}O_{14} + 4\,H_2O = 2\,C_{15}H_{10}O_6 + C_6H_{14}O_6.$$

This formula requires C = 63·34, and H = 3·81 per cent., whilst Schmid obtained C = 62·70; 62·77, and H = 4·35; 4·54 per cent. Perkin's values, C = 60·21, and H = 4·00 per cent., correspond more closely with $C_{36}H_{30}O_{16}$. The hydrolysis would then be represented as below:—

$$C_{36}H_{30}O_{16} + 2\,H_2O = 2\,C_{15}H_{10}O_6 + C_6H_{14}O_6.$$

As shown in the succeeding experimental portion of this paper, the analytical results yielded by the deposit from *Alphitonia excelsa* agree closely with the data quoted by Perkin; moreover, indications have been secured which point to rhamnose as a product of the hydrolysis. It is hoped, in continuing this investigation, to develop more satisfactory methods of hydrolysing the glucoside and to adduce further evidence regarding the constitution of this interesting natural product.

Experimental.

The substance forming the deposit was odourless, and its aqueous solution had a distinctly bitter taste. It was readily soluble in hot water, but only moderately so in cold water; whilst it was fairly soluble in cold alcohol, slightly soluble in ether, and practically insoluble in benzene. In order to prepare the pure substance, the deposited material was scraped from the wood and boiled with water. After filtration and keeping for some hours, the greater portion of the dissolved substance separated as a fine crystalline deposit. This was collected, washed with cold water, and purified by recrystallisation from hot water. The dry powder was afterwards treated with warm ether.

As thus prepared, the product was an almost colourless powder; it melted with decomposition at 218 – 219°, with preliminary darkening at about 200°. The aqueous solution gave a light yellow precipitate with lead acetate, and also with stannous chloride, and a brown precipitate with copper acetate: all these precipitates were readily soluble in acetic acid. The substance readily reduced Fehling's solution and ammoniacal silver nitrate solution upon heating. Its aqueous solution gave a green coloration with ferric chloride, which on the addition of very dilute sodium hydroxide solution changed through blue-purple to red as the final colour. These colour changes, together with the

other reactions enumerated, indicate that the substance is phenolic in character, with two hydroxyl groups arranged in the molecule in the ortho-position, after the manner of catechol. Further, the absence of methylated phenolic groups was proved by applying the method of Zeisel. In accordance with its phenolic character, the substance was soluble in aqueous solutions of the caustic alkalies, with rapid darkening due to oxidation. A similar change was noticeable upon painting the light pink timber of "Red Cedar" with similar solutions.[1]

The substance possessed dyeing properties, and when boiled with mordanted cloth the resulting colours were red-brown for chromium, and orange-yellow for aluminium: these colours were weaker than those given by quercetin glucosides, like myrticolorin, but resembled those of fisetin and its derivatives.

When the substance was boiled with dilute sulphuric acid the solution soon changed to a yellow colour and darkened considerably on longer boiling. Further examination showed the substance to be very resistant to the action of boiling dilute acids. Even when boiled for 15 hours very little hydrolysis had occurred: most of the original substance was recovered unchanged, and only a very small amount of an orange precipitate separated on cooling.

In an endeavour to characterise the sugar which was shown to be formed by hydrolysis, the following procedure was adopted: the sulphuric acid was removed by barium carbonate, and the unchanged material by lead acetate, the lead being removed in the usual way and the filtrate evaporated. The small amount of residue thus obtained

[1] The glucoside is uniformly distributed throughout the heart-wood of the timber, so that when washed with a very dilute solution of sodium hydroxide the wood is deeply stained, and when polished or varnished has a striking resemblance to "Queensland Maple," *Flindersia Chatawaiana*.

had an odour of sugar, and gave a somewhat impure osazone melting at 188 – 190°. The substance was thus shown to belong to the group of natural glucosides. With the aim of obtaining the sugar in greater quantity, a portion of the original substance was first boiled with dilute sulphuric acid for 4 hours, with a subsequent addition of hydrochloric acid and renewed boiling for several hours. The sugar formed by this treatment had increased somewhat in amount, and sufficient osazone was prepared to allow of its purification by one recrystallisation from dilute alcohol; it then melted at 179 – 182°, the indication thus being that the glucoside is very resistant to boiling dilute acids, and it becomes necessary to devise other methods, capable of effecting a more complete hydrolysis.

For further investigation of this glucoside it is unnecessary to depend upon its adventitious deposition in the cracks of unsound timber, as we have been able to separate it in quantity from the wood itself. The method adopted was to boil the thin shavings in water for some time, and to submit the concentrated filtrate to fractional precipitation with lead acetate. After removing the first fraction, which consisted of a dark brown precipitate, a further addition of acetate produced a light yellow precipitate from the glucoside: this was separated, washed, and then run into boiling dilute sulphuric acid, in the form of a thin cream. The filtrate from the lead sulphate was then repeatedly extracted with ether, and after removing the ether by distillation the residue was recrystallised from boiling water. The resulting product melted at 218 – 220°. Thus, although fisetin may be present in the timber in small amount, the main product isolated in this way is evidently the glucoside noted above (compare Perkin, *loc. cit.*).

When maintained at 150° for 3 hours, the substance underwent a loss of weight corresponding closely with

three molecules of water, calculated from the formula $C_{36}H_{30}O_{16}$. An analysis of the anhydrous substance gave C = 59·82 and H = 4·31 per cent.: $C_{36}H_{30}O_{16}$ requires C = 60·18 and H = 4·45 per cent. A specimen which had been dried at 130° for 1½ hours gave C = 59·15 and H = 4·00 per cent.

The substance readily formed a crystalline potassium salt when treated with potassium acetate in hot alcoholic solution. After drying at 140°, it was found to contain K = 10·12 per cent. A specimen of the potassium salt prepared by mixing cold alcoholic solutions of the glucoside and potassium acetate and allowing the mixture to stand overnight contained K=10·17 per cent.: $C_{36}H_{28}O_{16}K_2$ requires K=9·85 per cent. The potassium salt was insoluble in boiling alcohol.

An ammonium salt was also formed by dissolving the glucoside in a large excess of concentrated ammonia solution and keeping for some hours. This derivative was a crystalline powder, insoluble in boiling alcohol. It melted with evolution of ammonia at 125−126°, and gave an alkaline reaction when dissolved in water. It contained N=3·5 per cent.: $C_{36}H_{28}(NH_4)_2O_{16}$, or $C_{36}H_{36}O_{16}N_2$, requires N = 3·7 per cent.

It thus appears that the molecule of the glucoside contains two fisetin nuclei united with one sugar nucleus, and that only one phenolic group in each fisetin rest is effective in giving rise to metallic derivatives. It may be recalled that quercetin, which has five phenolic groups in its molecule, yields a mono-potassium derivative, and many similar instances have been recorded.

Acetylation of the glucoside was accomplished in the customary manner, the product being finally purified by crystallisation from alcohol. It was a colourless crystalline

solid, melting at 75 – 77°. Upon combustion analysis it gave C = 58·54, and H = 4·43 per cent.: $C_{36}H_{24}O_{16}(CO{\cdot}CH_3)_6$, or $C_{48}H_{42}O_{22}$, requires C = 59·35, and H = 4·35 per cent. This result, although not to be accepted as conclusive, indicates that the derivative might be a hexa-acetyl derivative of the glucoside.

When the glucoside was treated with concentrated nitric acid in the cold, it soon reacted with the production of a deep brown colour. When the solution was heated it became lighter in colour and nitrous fumes were evolved. After subsequent dilution with water and boiling, oxalic acid was detected in the solution.

We have pleasure in acknowledging our indebtedness to the Curator of the Sydney Technological Museum for the material used in the investigation, and Messrs. R. S. Hughesdon, B.Sc., and F. Lions, of the Sydney University, for kind assistance with the analyses.

ON AN OLIVINE-BEARING QUARTZ-MONZONITE FROM KIANDRA, N.S.W.

By W. R. BROWNE, D.Sc., and W. A. GREIG.

With Plate XIV.

[*Read before the Royal Society of N.S. Wales, December 6, 1922.*

Introduction.

The association of olivine and primary quartz in an igneous rock is a comparatively rare phenomenon. Apart from the occurrence of the iron-olivine, fayalite, in cavities in rhyolites, olivine in rocks other than basic appears to be confined mainly to lavas and quickly-cooled intrusions. Theoretically olivine is unstable in the presence of free silica, the tendency being for the orthosilicate to take up sufficient silica to convert it into the metasilicate, enstatite or hypersthene. Hence the association of olivine and free quartz, even in small amounts, in a plutonic rock is of interest, and this circumstance, coupled with the fact that so far as we are aware, the rock under consideration is only the second monzonitic type yet described from this State, will perhaps serve as some justification for the detailed nature of this communication.

The rock in question outcrops at Pollock's Gully, in the township of Kiandra, on the Southern Tableland of New South Wales. It is briefly mentioned by Mr. E. C. Andrews, B.A., in his report on the Kiandra Lead, under the name of norite,[1] and indeed the specimens which have been investigated by us were probably collected by Mr. Andrews. They have been made available through the courtesy of the Curator of the Mining Museum, Mr. G. W. Card, A.R.S.M.

[1] N.S.W. Depart. of Mines, Mineral Resources, No. 10, 1901, p. 17.

From Mr. Andrews's description it is evident that the field relations of the rock are by no means clear, and, as a matter of fact, the specimens available comprise both quartz-monzonite and other types which we have designated monzonite-porphyry, all of which are quite plainly closely related, judging from their mineralogical features. Mr. Andrews mentions an association, at one spot, of the norite with a small granite boss, but as no specimens of the latter appear to have been collected it is impossible to say whether this association has any genetic significance.

Petrographical Descriptions.

The quartz-monzonite is a phanerocrystalline rock of medium, fairly even, grainsize, and resembles a diorite in appearance.

A Rosiwal measurement of a thin section gave the following approximate mineral constitution in volume percentages:

Plagioclase	40·1	Hornblende ...	7·2
Orthoclase	17·9	Biotite	6·3
Quartz	5·9	Magnetite ...	·7
Augite	15·8	Olivine	·6
Clino-hypersthene (?)	5·5	Apatite less than	·1

These figures are nothing more than rough approximations, but they will serve to give some idea of the quantitative relationships of the constituent minerals.

Plagioclase is in well formed thick prisms and tables, averaging about ·7 mm. in length, clear and fresh, showing albite twinning and marked chemical zoning. Measurements indicate quite a considerable range in the composition of the different zones, from labradorite ($Ab_{37}An_{63}$) at the centre to oligoclase or even albite at the periphery. Slight oscillation of composition is noticed.

The orthoclase, which is untwinned and generally clouded by decomposition, envelopes the ends of the plagioclase

crystals so as to produce typical monzonitic fabric. It is, like the quartz, always interstitial. The relations between these two minerals are hard to determine, since wherever a boundary between them occurs it is generally of non-committal character, but in one slide a small patch of micrographic intergrowth between the two was observed.

The pyroxenes present are of two kinds: in addition to augite there is another type, also apparently monoclinic, which is possibly clino-hypersthene. These two are very intimately associated and are similar in habit, occurring in grains or in subidiomorphic stoutish prisms, in places up to 3 mm. long but usually smaller. The minerals are much cracked, and both commonly show peripheral alteration to hornblende.

Parallel growths and intergrowths are common, the latter being sometimes rudely graphic, and the two minerals may be clotted or aggregated in glomeroporphyritic fashion, although strictly speaking there is no porphyritic fabric present. Where parallel growths occur the augite is usually enclosed in clino-hypersthene, indicating that it was the first of the two to separate from the magma. Occasional graphic intergrowths of two augite individuals in different orientations are to be seen.

The augite is of a greenish-grey colour in sections about ·04 mm. thick. It frequently exhibits repeated orthopinacoidal twinning, the lamellæ being sometimes irregularly bounded in part as if through interpenetration, and traces of basal striation and herring-bone structure show up in little patches where the mineral is slightly altered. Occasional traces of the pinacoidal (diallagic) striation are seen, but they are not common. Extinction angles up to 43° have been measured, and the double refraction is about ·025 and of positive sign. The optic axial angle is smaller than usual, a series of measurements, kindly made by Miss Ida

Brown, B.Sc., on thin sections, giving values for 2V between 40° and 49°. These characteristics would seem to indicate a diopsidic pyroxene higher than usual in MgO, approaching enstatite-augite in composition, although no very small optic axial angles were observed, as appears to be common in the case of this mineral.

The mineral in this rock which has in the past generally been regarded as hypersthene presents some unusual features. A goodly number of longitudinal sections show straight extinction, as one would expect in ordinary hypersthene, but many extinguish at angles up to and exceeding 20°. The characters of these sections agree in other respects with those of hypersthene: double refraction is weak, the polarization colours being low 1st order grey, with a negative sign; pleochroism is feeble except in thick sections, where there is a distinct colour change from pale greyish-green to a light apricot tint. Sections with practically straight extinction often show a kind of irregular patchy undulose extinction which in some cases seems to be due to or accompanied by extremely fine twinning striations. The sections extinguishing obliquely exhibit marked zoning between crossed nicols, and a corresponding slight intensification of colour in the peripheral portions in ordinary light. Measurements of the optic axial angle by Miss Brown showed 2V to lie between 51° and 56°, which is lower than usual in either rhombic or monoclinic pyroxene.

The possibility suggests itself that these sections, including those with straight extinction, represent clino-hypersthene, a monoclinic form of the magnesia-iron pyroxene, corresponding to clino-enstatite, which is the stable form of the pure magnesia pyroxene at high temperatures in laboratory experiments,[1] and has also been found in meteorites.

[1] Allen, Wright and Clement, Amer. Jour. Sci., Ser. 4, Vol. xxii, 1906, pp. 385–438.

The hornblende deserves more than passing notice. Although at first sight it would be classed as uralite, a closer scrutiny must cause the revision of this opinion. Certainly it has many of the attributes of secondary hornblende. For example it is quite evidently in many cases being formed at the expense of pyroxene, the junction with the latter being irregular and ill-defined, and often marked by a discharge of secondary magnetite dust. Further, it appears in parallel circumgrowth to the pyroxene, and twinning in the latter is continued out into the hornblende, phenomena which are both mentioned by Rosenbusch[1] as characteristic of uralite.

But on the other hand certain features point to the mineral being primary. Though formed partly at the expense of the pyroxene it has not been wholly produced in this way, but has formed outgrowths from the latter mineral, the boundaries of which are clearly those of hornblende, a fact that is most evident in the case of cross-sections. Then again the mineral is not fibrous, as uralite should be, but compact, and it is sometimes twinned when there is no corresponding twinning in the pyroxene around which it is grown. Rosenbusch has pointed out that as amphibole is generally poorer than pyroxene in lime, during the process of uralitization the excess of lime may appear in epidote or some other lime-bearing mineral; nothing of this sort is found in the present instance. It is to be noted, too, that the hornblende outgrowths are generally moulded on plagioclase but idiomorphic towards biotite, orthoclase and quartz. Finally, inside the rim of hornblende the clinohypersthene is frequently seen to be altering to a felt of very pale green actinolitic fibres with comparatively weak birefringence. All these indications would go to show that

[1] Microscopical Physiography of the Rock-Forming Minerals. Iddings' Translation, 4th Edition, 1905, page 271.

the hornblende is of primary crystallization, separating out under conditions which rendered the pyroxene no longer stable. Duparc and Hornung[1] have referred to hornblende produced in such circumstances as uralite, but J.A.Thomson[2] discussing what is evidently a very similar occurrence to that now being described, questions whether this term should be applied to a mineral which is clearly primary. It seems to be largely a matter of the definition of the term "uralite," and although the present writers cannot speak with much authority on the subject, from the examination of a few cases of what seemed to be uralitization it appeared that while for the most part there was pseudomorphism of the pyroxene by the fibrous amphibole in parallel growth, with concomitant formation of epidote, still there was also evidence of independent growth on the part of the hornblende.

It would probably be safe to regard uralitization as at all events a post-consolidation process, and as the hornblende in the present instance must have been formed when only about 70 per cent. of the rock was crystallized it may fairly be classed as primary. The hornblende all has the same appearance whether surrounding augite or clino-hypersthene, and is pleochroic in pale yellow-green, green, and pale bluish-green tints, the last suggesting the presence of a little of the glaucophane molecule, possibly due to absorption of some albite substance from the magma.

Biotite is present in small crystals and grains, generally idiomorphic towards quartz and orthoclase, but moulded on the other minerals. It shows a strong tendency to attach itself to the peripheries of pyroxene grains, and very often has grown round a nucleus of ilmenite, other occasional

[1] Comptes Rendus, 1904, p. 223.

[2] Geol. Surv. of West Austr., Bull. 33, 1909, p. 132; *cf.* also Teall, British Petrography, p. 95, and Williams, Bull. 28, U.S. Geol. Surv., p. 41.

inclusions being apatite and a tiny colourless mineral, possibly zircon, surrounded by a pleochroic halo. Alteration of biotite to chlorite is sometimes seen. Tiny needles of apatite, not very abundant, are embedded chiefly in biotite, orthoclase and quartz.

Olivine occurs only as inclusions in the pyroxenes, chiefly but not exclusively in the clino-hypersthene. For the most part it gives little rounded or elliptical sections, often not more than ·2 mm. in diameter. These have been much altered to a green or brown, slightly pleochroic substance, with magnetite dust, but enough fresh examples are available to make the identity of the mineral certain. Rarely a larger grain is to be seen, scored with cracks filled with magnetite dust. Sometimes a pyroxene crystal will contain only a few olivine granules, at other times the inclusions are quite numerous, and while for the most part they are optically independent, in some cases adjacent granules extinguish simultaneously. A tendency to peripheral distribution of the olivine is noticeable in some pyroxene grains.

As regards the order of consolidation, it is evident that olivine crystallized first. A little felspar is sometimes found embedded in the pyroxene, so that it possibly started to crystallize in part before the latter. The two pyroxenes sometimes occur in graphic parallel intergrowth, but whereas in the parallel growths of the two minerals augite is completely enwrapped by clino-hypersthene the converse relationship has not been found. It would seem then that augite started first, clino-hypersthene subsequently commencing, and the two thereafter crystallizing simultaneously.

The bulk of the plagioclase separated after the pyroxene, although the indenting of some pyroxene edges by plagioclase indicates a little overlap. Hornblende was the next

to start separating, followed by biotite, then came orthoclase and quartz, in part at all events simultaneously. A little iron ore is embedded in pyroxene and plagioclase, but apatite seems to have remained in solution until the plagioclase had ceased to crystallize.

The rock which is referred to by Mr. Andrews in his Kiandra report as a norite is in many respects similar to the quartz-monzonite just described. In hand specimen it is darker in colour and has a porphyritic instead of a granular appearance. The qualitative mineral constitution is the same as that of the quartz-monzonite, and so are the internal characteristics of most of the constituent minerals, but the texture is different. Pyroxene occurs in two generations, and the same remark applies to the plagioclase, so that the rock has almost a porphyritic, or as Mr. Card suggests, a lamprophyric appearance. There are pyroxenes, both augite and clino-hypersthene, in crystals up to 3 mm. long, embedded in a groundmass of stout plagioclase prisms averaging about ·7 mm., the interstices between these being filled with quartz, or orthoclase, or more commonly with an aggregate of tiny plagioclase, pyroxene, magnetite and apatite crystals with interstitial quartz or orthoclase, or both.

Some conception of the relative development of the principal constituents may be obtained from the following results of a very rough Rosiwal measurement, the figures representing volume percentages :—

Pyroxene phenocrysts	24·0
Groundmass pyroxene	4·1
Biotite	4·7
Magnetite	2·1
Plagioclase, with orthoclase, quartz, and apatite	65·1
	100·0

It will be noticed that the relative proportions of light and dark constituents are very close to those of the quartz-monzonite. Although orthoclase and quartz are distinctly subordinate to plagioclase it is impossible to give definite figures for them, owing to the fineness of their grain making measurement difficult. Of the pyroxenes augite dominates over clino-hypersthene, and both minerals are represented in the groundmass. Olivine is present in about the same proportion as in the quartz-monzonite, and hornblende forms about one per cent. of the whole rock. The bulk of the plagioclase belongs to the first generation.

The pyroxenes of the first generation have precisely the same characters and mutual relations as those of the quartz-monzonite. The plagioclase has the same range of composition, but is perhaps slightly smaller in grainsize and less idiomorphic. The wonderful freedom from inclusions of the plagioclase of both rocks is noteworthy. Biotite is smaller, but otherwise behaves as before. Iron ore occurs in two generations, the earlier often acting as nuclei for biotite and the later being a constituent of the interstitial groundmass. Apatite in tiny hair-like crystals is much more abundant than in the quartz-monzonite. Orthoclase and quartz are always subordinate, but no slide has been examined which does not contain both. The orthoclase is occasionally idiomorphic against quartz, and instead of being homogeneous is often filled with little vermicular inclusions of (?) quartz, the whole resembling not so much the ordinary granophyric intergrowth as that which is known as myrmekite.

The order of consolidation appears to be somewhat as follows:—(1) olivine, (2) porphyritic pyroxene, (3) plagioclase, (4) hornblende, (5) biotite, (6) apatite and the pyroxene and plagioclase of the groundmass, (7) orthoclase, (8) quartz. Magnetite crystallised partly before the porphyritic pyroxene and partly along with the groundmass.

In this rock the groundmass forms much less than ten per cent. of the whole, but in a slide from another specimen very similar in outward appearance, it actually exceeds in volume the plagioclase of the first generation, so that the rock looks markedly porphyritic, with large phenocrysts of pyroxene and smaller ones of plagioclase set in a fine-grained matrix in which pyroxene and magnetite granules and microlites play a conspicuous part, as well as quartz, orthoclase, plagioclase and apatite. In this particular rock there is practically no hornblende, and biotite is much less important than in either of the rocks already described.

Probably this rock is best called a monzonite-porphyry, and the same name may perhaps be applied to the second type, intermediate in texture between this and the quartz-monzonite, although in this case the groundmass is very subordinate and the plagioclase crystals of the first generation are generally in contact with each other.

Chemical Composition of the Rocks.

Complete chemical analyses were made by one of us (W.A.G.) of the quartz-monzonite and of the monzonite-porphyry last described, with the results tabulated in columns I and II below:—

	I.	II.	III.	IV.	V.
SiO_2	57·18	57·08	57·80	56·91	54·90
Al_2O_3	14·13	13·62	16·43	15·54	17 44
Fe_2O_3	1·90	1·30	1·62	2·32	9·64
FeO	5·85	6·21	6·51	4·98	
MgO	7·00	8·07	4·14	5·71	3·26
CaO	7·64	7·54	7·21	5·80	6·96
Na_2O	2·36	2·50	2·35	2·45	3·50
K_2O	2·30	2·50	2·29	2·74	3·51
H_2O+	0·45	0·19	0·31	2·29	1·23
H_2O-	0·07	0·05	0·11	...	
CO_2	abs.	abs.	abs.	...	
TiO_2	0·60	0·65	0·70	1·09	0·71
ZrO_2	abs.	abs.	...	...	...
P_2O_5	0·21	0·21	0·19	0·21	0·51

	I.	II.	III.	IV.	V.
V_2O_3	0·04	0·07	...	...	...
SO_3	0·11	0·05	..	0·15	...
Cl	trace	trace	...	...	...
S	abs.	abs.	abs.	...	...
Cr_2O_3	0·03	0·02	...	...	...
NiO & CoO	trace	trace	0·03	...	. .
MnO	0·11	0·14	0·18	...	...
BaO	0·04	0·04	0·09	...	...
SrO	trace*	trace*	...	...	...
Li_2O	abs.	abs.	...	...	...
	100·02	100·24	100·03	100·19	
Sp gr.	2·927	2·937	...	2·791	

* Spectroscopic.

I. Quartz-monzonite, Kiandra, N.S.W. Analyst, W. A. Greig.

II. Monzonite-porphyry, Kiandra, N.S.W. Analyst, W. A. Greig.

III. Quartz-diorite, Tuolumne Co., California Analyst, Hillebrand.

IV. Enstatite-porphyrite, Bolmke Thal, Harz., Analyst, K. Hampe.

V. Brögger's average monzonite. Die Triadische Eruptionsfolge bei Predazzo, p. 51.

These figures, with the very concordant specific gravities, indicate that the two rocks are practically identical chemically, a state of affairs that was not so evident from the petrographical examination.

Calculated according to the C.I.P.W. system their norms and classifications are:—

	Quartz-monzonite.	Monzonite-porphyry.
Quartz...	... 7·98	4·68
Orthoclase	... 13·34	15·01
Albite ...	... 19·91	20·96
Anorthite	... 21·41	18·35
Diopside	... 12·79	14·80
Hypersthene	... 19·50	22·43
Magnetite	... 2·78	1·86
Ilmenite	... 1·22	1·22
Apatite	... 0·34	0·34
	II(III). 4(5). 3. 3(4)	"III. "5. 3. 3(4)
	Harzose.	Kentallenose.

Thus the slight chemical differences between the two rocks have separated them as far as class and order are concerned. This is due chiefly to the higher percentages of alkalies, and especially of magnesia, in the porphyritic rock, which have had the double effect of increasing the proportion of femic molecules in the norm, and of decreasing the amount of silica available for quartz.

Hypersthene is the dominant pyroxene, just the reverse of what is found in the mode. As only a small proportion of this normative hypersthene is contained in biotite and hornblende, it is evident that a good deal of it must be present in the augite of the rock, as was inferred on optical grounds.

Chemically the rocks are different from the normal types of monzonites, the iron and magnesia, and perhaps lime, being rather higher, and the alkalies rather lower than usual. This is brought out by comparison with Bröggers average monzonite, quoted in column V.

The rather exceptional composition of the rocks is also made plain by the fact that it is difficult to find in Washington's Tables any rocks, belonging to the same subrangs, that were at all closely comparable, two of the nearest being given in columns III and IV.

The Cooling-History of the Quartz-Monzonite Magma.

In the absence of detailed information as to the field-occurrence of the different rocks just described, it is perhaps rather futile to speculate as to their probable mutual relationships. It is perfectly clear, however, that they are closely connected genetically, and that they represent portions of the same magma cooled under different conditions, the monzonite-porphyry possibly representing a relatively rapidly-cooled marginal phase of the quartz-monzonite.

It is possible to give a reasonable explanation of the observed mineralogical peculiarities of the quartz-monzonite. N. L. Bowen,[1] generalizing from the results of a considerable number of laboratory investigations, has described the probable course of crystallization during the slow cooling of a body of basic magma, of the composition of a mixture of plagioclase and a rather magnesian pyroxene. He points out that the first mineral to crystallize is not pyroxene, but a member of the olivine group, which, on the temperature falling sufficiently to permit of the formation of pyroxene, gradually suffers resorption. He has also shown how in the later stages of the crystallization of such magmas, after the separation of plagioclase, hornblende and (if potash is present) biotite may be formed, with some quartz in addition.

On the basis of the principles enunciated by Bowen it is possible to some extent to trace the history of the Kiandra quartz-monzonite, although judging from the analyses the magma was not basic but intermediate in character. Originally, before crystallization, the magma was at a temperature above the crystallization-point of olivine, which was the first mineral to appear after cooling started. It continued to separate until a temperature was reached at which solid pyroxene, rather magnesian, was in equilibrium with the magma. As soon as this appeared resorption of the olivine commenced, and it continued with the concomitant formation of pyroxene. It was where the dissolving olivine produced magnesia-rich patches in the magma that the pyroxene formed, eventually enwrapping the remnants of olivine in many cases, and thus removing them from the corrosive influence of the magma. The olivine not protected in this way went into solution, and that is why the olivine in the rock invariably occurs as

[1] Journ. Geol. Vol. 23, 1915, Supplement.

inclusions. When the pyroxene was almost completely crystallized the plagioclase made its appearance and continued to solidify until the plagioclase material in the magma was nearly all exhausted.

The continued crystallization had the effect of concentrating the water and other mineralizers, so that in time the anhydrous pyroxene gave place to hornblende, which began to crystallize, partly from the small amount of ferro-magnesian material still present in the magma, and partly at the expense of the now unstable pyroxene.

The amphibole, as is usual in such cases[1] crystallized mostly around and in parallel circumgrowth to the pyroxene, and, judging from its colour, absorbed some of the albite molecule still present in the magma. At a later stage the concentration of mineralizers caused the partial dissociation of the orthoclase molecule, which united with the ferro-magnesian silicate molecules to form biotite. The latter may have formed at the expense of the solidified pyroxene and amphibole, but there is no evidence that this is so; though the biotite often clings closely to the pyroxene and hornblende, much of it occurs quite detached from these.

The formation of hornblende, and later of biotite, instead of pyroxene, set free a certain amount of silica, and the final stage of consolidation was the crystallization of the residue of orthoclase, and of the remaining silica as quartz.

The presence of olivine in the rock is therefore due to the richness of the magma in the hypersthene molecule, or, putting it another way, to the high value of the ratio magnesia: femic lime. The quartz is due largely to the relatively high silica percentage of the magma, but also, though in a very subordinate degree, to the formation of

[1] *cf.* J. A. Thomson, Geol. Surv. of W. Aust. Bull. 33.

hornblende and biotite. The present example would seem to show that olivine can crystallize out from magmas containing an appreciable proportion of free quartz, although of course the possibility must be considered that the magma may have been acidified by the gravitative settling of some olivine.

The discrepancy between normative and modal quartz is rather puzzling. If the scheme of crystallization outlined above is correct, then the norm, which represents crystallization under anhydrous conditions, should be poorer in quartz than the mode by the amount formed as a by-product in the crystallization of hornblende and biotite. But in fact the Rosiwal analysis shows something less than 6 per cent. by weight of quartz, whereas the norm contains nearly 8 per cent. It may be that the quartz is not uniformly distributed through the rock, and that the portions measured were poorer than the average in this mineral.

The comparative lack of hornblende and biotite in the analysed monzonite-porphyry is probably to be regarded as due to its having cooled relatively quickly and without the concentration of water and other mineralizers which exercised such an important influence on the quartz-monzonite.

The positions of apatite and iron ore in the crystallization order deserve some notice. These minerals are usually among the first to crystallize from igneous magmas, but in the present instance they appear almost entirely as inclusions in the later minerals, biotite, orthoclase and quartz, and seldom (in the case of apatite, never) in pyroxene or plagioclase. This is particularly noticeable in those rocks containing a groundmass, the apatite and most of the iron ore being concentrated in the spaces between the larger felspars, which are conspicuously free from inclusions. It may be that, as suggested by Elsden for the apatite of

the St. David's Head quartz-dolerites,[1] there was a repulsion between the crystallizing pyroxene and felspar on the one hand, and the small minerals of early crystallization on the other, whereby these latter, which would ordinarily have become inclusions, were pushed outwards away from the other minerals.

It is quite probable, however, that in the conditions existing during crystallization, possibly on account of the presence of mineralizers, the apatite and iron ore remained soluble until a fairly late stage in the consolidation. This late crystallization of apatite has been noticed not merely in the quartz-bearing basic rocks such as those described by Elsden, but in others in which water must have been present, such as the analcite-dolerite from Currabubula,[2] and the so-called essexite from Prospect,[3] in both of which rocks a good deal of the apatite is found enclosed in the primary analcite. In this connection it is perhaps significant that the pegmatitic facies of basic intrusions, where such exist, may sometimes be rich in apatite and iron ore.

Conclusion.

The crystallization of this quartz-monzonite, then, epitomizes the course of crystallization of a large body of magma, and its differentiation into a series of rocks ranging from basic to acid, as pictured by Bowen in the paper already referred to, and as sometimes found in the field. In these cases the removal of the olivine has been accomplished largely by sinking under gravity in the still liquid magma, whereas in the present instance the same result has been achieved through the enclosure of the olivine by pyroxene.

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[1] Q.J.G.S., Vol. 64, 1908, p. 289.

[2] Proc. Linn. Soc. N.S.W., Vol. 45, 1920, p. 421.

[3] This Journal, Vol. 45, 1911.

It would thus appear that the association of olivine and primary quartz in the same rock may be brought about in one of two ways:

(*a*) As in the case of the Kiandra quartz-monzonite just described.

(*b*) Where there has been sinking of olivine crystals in a magma-reservoir, an eruption of the still liquid, relatively acid, top portion of the magma might include some of the already crystallized olivine caught up from the lower levels. Hence might arise, for example, the presence of olivine nodules, or, exceptionally, isolated olivine grains in a quartz-dolerite: these would be cognate xenoliths and cognate xenocrysts respectively. An occurrence of olivine in a quartz-dolerite from Adélie Land, Antarctica, described by one of the authors, is probably to be explained in this way.

The olivine sometimes found in intermediate volcanic rocks whose silica percentages would have permitted the crystallization of pyroxene, is possibly due to interrupted intratelluric crystallization. Under these circumstances some or all of the olivine, which formed before eruption of the magma as a flow or a minor intrusion, would tend to persist, rapid cooling preventing complete resorption, and perpetuating the unstable phase. In this way may perhaps be explained the olivine in the dacites of Mount Shasta, California,[1] and that in the pitchstone-porphyries of Arran, described by Scott.[2]

But in a plutonic magma where slow cooling obtains and equilibrium adjustments are possible, unstable tend to be replaced by stable minerals, and hence in rocks of deep-

[1] Iddings, Igneous Rocks, Vol. 1, p. 142.

[2] Geol, Mag. N.S. Dec. VI, Vol. 1, 1914, p. 319.

Fig. 1.



Fig. 2.



Fig. 3.

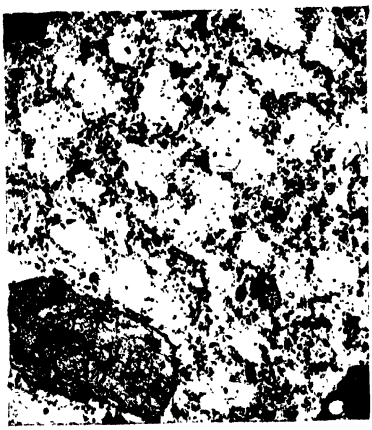


Fig. 4.



H. Gordon Gooch.

seated origin the association of olivine and quartz must be necessarily exceptional.

EXPLANATION OF PLATE XIV.

Magnification in each case 14½ diameters.

Fig. 1. Quartz-monzonite. Ordinary light. Note the augite in the lower left-hand corner, filled with olivine granules and surrounded by a hornblende rim.

Fig. 2. Same as Fig. 1, between crossed nicols. The interstitial material, wrapping round the plagioclase in typical monzonitic fashion is largely orthoclase, with a little quartz.

Fig. 3. Monzonite-porphyry. Ordinary light. The plagioclase of the first generation is notably free from inclusions and the augite phenocrysts have no hornblende rim.

Fig. 4. Same as Fig. 3, between crossed nicols, showing the disposition of the groundmass. Note the multiple twinning and the composite nature of the pyroxene phenocryst.

NOTE ON THE OCCURRENCE OF CALCITE IN A BASALT FROM THE MAITLAND DISTRICT, N.S.W.

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With Plate XV.

[*Read before the Royal Society of N. S. Wales, December 6, 1922.*]

SOME recent petrological investigations by the author in regard to the lavas of the Carboniferous and Permo-Carboniferous systems in the Lower Hunter River district have resulted in the discovery of a number of features of considerable interest. Among other things it has been observed that albitization and allied magmatic processes have been at work on many of the Carboniferous eruptive rocks, and more particularly on the basic rocks which are supposedly co-magmatic with these, the amygdaloidal basalts which are interbedded with the sediments immediately overlying the topmost or glacial stage of the Kuttung division of the Carboniferous rocks.

In these amygdaloidal basalts, whose field-occurrences have been described and mapped by Professor Sir Edgeworth David,[1] there has been much conversion of basic plagioclase into albite, but in addition analcite and another zeolite, which appears to be natrolite, commonly take the place of the original basic felspar, or even apparently of the replacing albite. The vesicles are filled with the same zeolites, and occasionally with calcite and quartz, and in some cases the interstitial spaces between the felspars and other minerals in the non-vesicular varieties are occupied by the zeolites, which must be regarded as magmatic and primary.

[1] Geol. Surv. of N.S.W., Memoir No. 4.

These rocks had frequently been observed to contain little patches of calcite in the groundmass, but as a certain amount of alteration had generally taken place the presence of the calcite was put down to purely secondary causes. However, a specimen recently collected was found to be so rich in this mineral, while a good proportion of the rock was reasonably fresh, as to cause a suspicion that something else than weathering was responsible for its presence.

The specimen in question was found about three miles north of West Maitland, a short distance south of where the road to Eelah crosses the North Coast Railway. On the property of Messrs. Comerford, between the homestead and the overbridge, is a small quarry, and in a creek, about thirty yards or so uphill from this, is the spot from which the rock was taken.

The basalt is part of a thick flow, or series of flows, shown on Professor David's map as extending for a considerable distance to the north-west of the spot described above, and at this place it underlies directly, with a dip to the east, some coarse tough calcareous conglomerate belonging to the Harper's Hill horizon, and very abundantly fossiliferous, particularly in *Aviculopecten*.

In this mass of lava amygdaloidal and massive varieties appear to alternate to a certain extent, indicating the possibility of a number of successive flows.

The calcite-bearing type under present consideration is massive, and the rock directly above it is amygdaloidal. In the latter rock the plagioclase has been largely converted into analcite and natrolite (?), and the olivine is represented by pseudomorphs of green pleochroic iddingsite (?). A remarkable feature of the rock is the perfect freshness of the pale greyish-green augite. The spaces between the larger crystals and grains are filled partly with fine aggregates of felspar, ilmenite and indeterminate material, partly

with analcite or fibrous-radial natrolite, and partly with fibrous chlorite, often enclosing a core of analcite; rarely is calcite found. The vesicles of the rock are filled with analcite, natrolite or calcite, and are often lined with chlorite. (Plate XV, figs. 1 and 2.)

The calcite-rich rock is massive, and consists mostly of plagioclase, with augite, calcite, olivine and ilmenite in that order of relative abundance. The plagioclase, which must constitute more than half the rock by volume, is in laths occasionally attaining a length of 2 mm., and of a composition at least as basic as $Ab_{45}An_{55}$. It is much affected by alteration, the alteration products being irregularly distributed and often somewhat decomposed. In some places they are evidently albite, in others analcite, but elsewhere a colourless mineral of distinctly lower refraction but stronger birefringence than the felspar: this may be natrolite.

Augite is in small prisms and granules of a yellowish-green colour, with observed extinction angles up to 40°, and without noticeable pleochroism. To a slight extent it is moulded by the felspar, but mostly it is interstitial and sometimes slightly ophitic towards the latter Olivine has been converted almost completely into brownish-red translucent pleochroic hæmatite, often partly rimmed by an opaque margin of the same, the original olivine having evidently been a highly ferriferous variety. The primary iron ore is ilmenite, with skeletal habit.

The interstices between the felspar laths may be filled with augite and ilmenite, and sometimes with a green chlorite-like substance, but for the greater part there is a mesostasis of calcite, which makes up about 13 per cent. by weight,[1] or 14 per cent. by volume, of the whole rock.

[1] Based on a determination of CO_2 kindly made by Mr. G. J. Burrows, B.Sc., of the Department of Chemistry, University of Sydney.

The calcite is granular, and fills the irregular interstices either as single grains or as two or more grains. It is often twinned, and may show a kind of undulose extinction reminding one of a vague and ill-defined brush, such as is seen in spherulitic aggregates. The interstitial spaces filled by the calcite are up to 2·5 mm. in length and are very irregularly bounded, quite unlike steam-cavities. Felspar and other minerals often project far into the calcite and are sometimes practically isolated by it (Plate XV, fig. 3). In places the calcite filling has perfectly sharp and straight boundaries against the felspar, but elsewhere the latter has been corroded, and partially replaced by the carbonate.

All the circumstances here point to the calcite being of magmatic origin; the mineral plays an interstitial *role* just as quartz does in a granite, or the quartz-felspar intergrowth in a quartz-dolerite, or the primary analcite in an analcite dolerite, and, judging from its appearance in thin section, has as much right as they to be considered primary. Again, the fact that the calcite forms such an unusually high proportion of the whole rock means that without it the rock would be a mere network of crystals, with considerable empty interstitial space, a highly improbable state of affairs in a rock just consolidated. When we add to this the fact of the complete enclosure of certain of the crystals in calcite the conclusion seems inevitable that the latter is primary. Alternatively it might be suggested that the calcite replaces some other interstitial material such as glass, but there is no evidence of this either from the associated rocks, or in the shape of relics of replace material in the rock itself.

The history of the rock-mass in its present condition would appear to be somewhat as follows:—After the consolidation of the principal constituents as a network or sponge-like mass of felspar, augite, olivine and ilmenite,

the strongly sodic residual magma, containing among other constituents alumina, silica, carbon dioxide and much water, attacked the already crystallized rock, or those portions susceptible to its influence. The felspar was albitized, and the olivine altered, while the augite was for some reason left untouched. This immunity of the augite, by the way, is a remarkably constant characteristic of many albitized basic rocks which have come under the author's notice. Even the albite became unstable under the conditions obtaining, for it was subsequently attacked and replaced by zeolites. The residual mother liquor, its work of substitution done, and enriched and modified by the assimilation of material from the olivine and felspar, eventually deposited its mineral constituents in order of increasing solubility in the interstices of the crystal network and in the steam-cavities. Thus as the temperature fell chlorite was deposited, then the soda-zeolites natrolite and analcite (in what order it is not clear), and lastly calcite.

If, as seems possible, the amygdaloidal rock referred to above really represents the top portion of a flow, of which the calcite-rich basalt is a lower portion, then it seems as if the chlorite and the hydrous silicates were mostly deposited nearest the cooling surface and the calcium carbonate eventually concentrated at a lower level.

It would thus appear that the solutions from which the calcite was deposited were essentially magmatic, and were really the same as those responsible for the chlorite, analcite and natrolite. This being so, the question arises whether the calcite should be regarded strictly as primary or as a result of the reactions referred to by Sederholm as "deuteric."[1] Certainly, if the view as to its origin stated above is correct, the calcite has been produced as a result of the alteration of primary minerals, but on the other hand

[1] Bull. Comm. Géol. Finlande, No. 48, 1916.

its crystallization began when the rock was not more than 86 per cent. crystallized, and again, it has been shown, experimentally and otherwise, that in some igneous rocks, certain of the minerals of later crystallization have resulted from interaction between the magma and minerals already crystallized from it, which for some reason have become unstable.[1] It would probably be difficult to define the limits separating primary and deuteric crystallization, as the two stages appear to grade into one another. However, in the present case, in view of the fact that the calcite forms such a large proportion of the rock, and that it is essentially not a replacement but an interstitial filling, there is surely justification for regarding it as primary.

It is interesting to note in passing that Holmes, in investigating the lavas of Mozambique, came to the conclusion, from the nature of their vesicle-fillings, that the alkaline basalts must have been crystallized from a magma containing much carbon dioxide,[2] a state of affairs which must be postulated in the present rock-mass, which has very evidently alkaline affinities, and indeed has much in common with the spilites.

Vesicle-fillings of calcite have been noted by the author in other rocks which have been affected by wandering magmatic solutions. At the village of Gosforth, about eight miles north-west of West Maitland, there is a flow of basalt, just a little distance stratigraphically above the Lochinvar shales: in its upper parts it is albitized and interstitial natrolite is found, but another and lower phase of the flow contains unaltered basic plagioclase, and its vesicles are filled with calcite.

[1] See, for example, Bowen, Journ. Geol., Vol. 23, 1915, supplement. p. 39, etc.; Duparc and Hornung, Comptes Rendus, Vol. 139, 1904, p. 228; Thomson, Geol. Surv. of W. Aust., Bull. 33, 1909, p. 134.

[2] A. Holmes, Q.J.G.S., Vol. 72, 1916, p. 253.

Calcite is often found as a central filling to the zeolite-lined cavities in the Prospect intrusion, which is an essexite, or more properly perhaps an analcite-dolerite, and the author has found, in an albitized facies of the Saddleback dolerite outcropping at Port Kembla, calcite filling vesicles that are lined with chlorite encrusted by little prisms of albite.

In all these instances the rocks are alkaline in their affinities, and the most probable view of the origin of the calcite is that it was derived from the residual magmatic solutions which had attacked the lime-bearing felspars.

EXPLANATION OF PLATE.

Magnification in each case : 14½ diameters.

Fig. 1. Microphotograph of a section of the basalt overlying the calcite-bearing type. About the middle of the picture are interstices filled with analcite and lined with chlorite. At the bottom is an interstitial fibrous-radial zeolite. Ordinary light.

Fig. 2. Same as Fig. 1 between crossed nicols. The dark portions represent felspar which has been replaced by analcite, while in the light-coloured laths the replacing material is natrolite(?). The interstices filled with isotropic analcite and lined with chlorite show up well.

Fig. 3. Section of the calcite-bearing basalt, showing the interstitial disposition of the calcite (white). Most of the dark patches are olivine converted into dark red hæmatite. Note the fresh augite. Ordinary light.

Fig. 1.



Fig 2.



Fig. 3.



[*H. Gordon Gooch.*

NOTES ON THE BACTERIOLOGICAL ASPECT OF PASTEURISATION OF MILK FOR CHEDDAR CHEESE-MAKING.

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(Communicated by R. D. WATT, M.A., B.Sc.)

[*Read before the Royal Society of N.S. Wales, December 6, 1922.*]

EXPERIMENTS have been conducted by Mr. T.H. Atkinson of the Dairy Branch, Department of Agriculture and the writer of this paper with a view to determining for this State the influence of the pasteurisation of milk on the yield and quality of cheese. Work along similar lines has been done elsewhere, but few bacteriological data are available and none have apparently been published in Australia.

The figures now given are recorded from work done at the Hawkesbury Agricultural College and continued at the Moruya Co-operative Dairy Company's factory by courtesy of its directors. The results are those obtained during the Winter and, presumably, would have been even more marked had they been the record of Summer experiments.

General.

Pasteurisation has for its object the killing of the great majority of the bacteria present in the raw milk, thus presenting a relatively germ-free milk for inoculation by starter with those bacteria which experience has shown to be intimately linked up with good quality in cheese. As indicated in a previous article,[18]* the alternative is a much improved bacterial quality of the raw milk. Careful observance of the factors necessary for such an improve-

* Reference is made by number to literature cited p. 297.

ment is uncommon under present Australian conditions, and to bring about their common observance would need years of educational work among farmers as well as regulatory action under a Dairy or other Act. With average milk now reaching cheese factories, "fast" batches and great losses by spoilage are commonplace in cheese made from raw milk. Pasteurisation prevents these conditions by killing out the vast majority of the *Streptococcus lactis* group which are mainly responsible for "fast" batches, and members of the *Bacillus coli-cerogenes* group which cause most spoilage. Inoculation of the pasteurised milk with a good quality starter places subsequent fermentations under the control of the cheese maker. The problem is more complex than that associated with butter-making because of the critical nature of casein coagulation by rennet in the cheese-making process. This coagulating property of casein is affected by heating, and the ability of the coagulum to shrink and expel whey is also adversely affected by the degree of heat used in pasteurisation. Whereas temperatures of 200° Fah. and above have been and are used with success in the regenerative pasteurisation of cream for butter-making, experiments elsewhere,[1, 2] and by Mr. T. H. Atkinson in this State, have shown that the most satisfactory temperature for the regenerative pasteurisation of milk for cheese-making is, under average factory conditions, about 165° Fah., higher temperatures causing considerable difficulty in the manufacturing process and giving an unsatisfactory product.

College experiments conducted during 1921 with the then Cheese Expert, Mr. J. G. McMillan, and during the present year with Mr. Atkinson, have shown that the bactericidal efficiency of flash methods of pasteurisation at this temperature is satisfactory. The writer has not access to unpublished figures of Messrs. McMillan and Randell.

The experiments of C. W. Brown and K. Peiser[3] indicate that the heat death-point for the *B. coli-cerogenes* group is raised 14·4° F. by whole milk. In view of this factor in killing the harmful gas-formers, it is satisfactory to note that no typical colonies of this critical group in cheese manufacture developed on whey agar plates containing 1/10 c.c. of the pasteurised milk.

Mohler[4] and others have shown that *B. tuberculosis* can survive the raw milk process of cheese manufacture, and Mohler is reported to state that a generalised case of tuberculosis was produced in a guinea pig by an inoculation of *B. tuberculosis* obtained from cheese seven months old. With an acidity (expressed as lactic acid) not greatly in excess of ·25% it is doubtful if this temperature of 165° F. used regeneratively will kill all cells of *B. tuberculosis* present in the milk. Were there definite evidence of the killing out of the tubercular bacilli by this process, the public health aspect would somewhat strengthen the case for the pasteurisation of milk for cheese-making. The demand for dairy products free from living cells of *B. tuberculosis* is a feature of steady growth. Williams and Harries[5] state that on the evidence then (1915) available, from 1/4 to 1/3 of human tubercular disease, other than that of the lungs, is due to the "cow" type.

College Experiments.

These experiments included trials of pasteurisation by the flash method at 155°, 165° and 175° F. and the holding process for thirty minutes at 145° F. This latter process was the most bactericidally efficient (99·94%); the flash methods at the two higher temperatures were satisfactory averaging 99·89%.

During the cheese-making process petri dish cultures were made from the milk before and after pasteurisation, from the raw and pasteurised milks at renneting, and from

the respective wheys five minutes after "cutting" and at "running." The media used were whey agars containing 1% of peptone (Baker's), 1·5% of agar and ·5% of dairy salt dissolved in a litre of whey obtained from the college cheese vats immediately after the cutting of the curd. The media were sterilised by the intermittent method. Incubation was at "room" temperature for seven days; "room" temperature under our conditions almost certainly averages some degrees higher than that of northern Europe and the more northern of the United States.

Owing to the fact that the College milk is produced under conditions much superior to those ruling on dairy farms and its abnormal richness (being drawn from a Jersey stud), it was blended with farmers' milk.

Hawkesbury Agricultural College.

Period in cheese-making process.	Average count per c.c.		Maximum count per c.c.		Minimum count per c.c.	
	Raw	Past'd.	Raw	Past'd	Raw	Past'd
Total micro-organisms in the mixed milks...	308000	1500	617000	11150	16000	132
Micro-organisms other than *Sc. lactis*, in the mixed milks at renneting.	109000	2750	268000	6000	21000	less than 100
Micro-organisms other than *Sc. lactis*, in wheys at "cutting."	113000	2080	394000	10500	4800	ditto
Micro-organisms other than *Sc. lactis*, in wheys at "running."	28000	1400	72000	3200	3300	ditto
Micro-organisms other than *Sc. lactis*, in one day old cheese.	* 927000	* 136000	* 3500000	* 750000	* 35000	*less than 1000

Per gramme

In the table presented above the figures represent those obtained from a College series of twelve "raw" and twelve "pasteurised" cheeses manufactured during late May and early June. Each cheese was approximately forty pounds in weight.

The table shows that the bactericidal efficiency of pasteurisation was satisfactory; the average given includes some figures obtained from the flash method at 155° F. The reduction in the number of bacteria as a consequence of pasteurisation is marked at all stages of the process. The most significant figures are those of the "other groups" content of the raw and pasteurised milks at renneting, 109,000 and approximately 3,000 respectively. Litmus and brom-thymol-blue milk inoculations showed that the proportion of harmful gas-producers of the *B. coli-cerogenes* type present in "other groups" was much higher in the raw than in the pasteurised milk.

Moruya Experiments.

At the Moruya Co-operative Cheese Factory the quantity of milk used was much greater, the daily total varying from 4480 to 5530 lbs. Cheese was made from the raw and pasteurised milks, the former serving as a check. Each batch was controlled in the way calculated to give the most satisfactory product. Vats and other conditions in common were alternately used for raw and pasteurised batches. The temperature at which the regenerative pasteuriser was run had extreme variations of 161° and 170° F. but did not remain more than a degree from 165° F. for a longer period than one minute except in the case of the first batch.

Owing to flood conditions during the experiment, some of the milk came in somewhat stale, and the chemical and physical nature of the milk solids may have been affected by the hard conditions experienced by the cattle.

Transport over rough roads by service car caused some petri dish cultures to be damaged and the records given in the following tables are not complete.

Moruya Co-operative Cheese Factory.

Count of total micro-organisms present in the raw and pasteurised mixed milks.	
Raw Milk.	Pasteurised Milk.
610,000	875
1,280,000	4,080
654,000	512
612,000	500
206,000	7,220
672,400	Average 2,650

To obtain a better comparison with "raw" vat conditions, the samples of pasteurised milk were taken from the bulk after its passage over the cooler; the actual efficiency of the pasteuriser would then be somewhat higher than the percentage (99·6) calculated from the figures. Cooling to renneting temperature is an essential part of the process, and contamination during cooling is legitimately recorded against the pasteurisation process. The investigations of Haglund[6] may indicate that cooling to a much lower temperature than that of renneting improves the product. Sammis and Bruhn[1] in their classical bulletin on the subject obtained an efficiency of over 99% using 165° F. with 1912 flash pasteurisers. MacInnes and Randell[7] using the flash method at 180° F. obtained an efficiency at the outlet of the machine of 99·98% for cream.

The work of Ayers and Johnston[8] indicates that some of the lactic streptococci may survive flash pasteurisation at 165° F., while Weigmann, Wolff, Treusch and Steffen[9] state that the results of their investigation go to show that

after heating milk for thirty minutes at 140° to 145° F. the lactic acid bacteria are present in much greater proportion to the remaining organisms than in the raw milk. There is no evidence apparently available to confirm this observation for regenerative pasteurisation at 165° F. MacInnes and Randell[7] state that 24,500 out of a total of 24,700 survivors from flash pasteurisation at 180° F. produced only slight acidity without noticeable taste or odour at the end of three weeks.

In one case mould colonies were present in the cultures. These were probably a reinfection from a nearby curing room. Tom and Ayers[10] consider that the pasteurisation for thirty seconds at 165° – 175° does practically destroy the spores of *Aspergillus*, *Circinella*, *Mucor* and *Penicillium* species experimented with by them.

Moruya Co-operative Cheese Company.

Micro-organisms other than *Streptococcus lactis* (Lister) present in milk at time renneting.

Raw Milk.	Pasteurised Milk.
700,000	5000
212,500	6000
1,515,000	130,000
*	252,000
1,025,000	14,000
863,125†	39,000†

* Petri dishes broken in transit. † Average of four.

One of the beneficial influences of the pasteurisation process in cheese-making lies in the comparatively clear field left for desirable bacteria in the processed milk. These bacteria greatly predominate in the milk at the time of coagulation owing to the addition of starter to this cleared field. Once the coagulum has been formed it is of course almost impossible to introduce any new bacterial type, and

little control can be exercised over the relative activities of the contained bacteria during stirring, cheddaring, salting and pressing. Hence the essential nature of a pronounced predominance of desirable types of bacteria at the time of coagulation.

Pasteurisation's other great advantage is that milks which would ordinarily give rise to fast working batches owing to the rapid production of lactic acid by the high number of contained organisms, are brought under control by the killing of the vast majority of these and their replacement by the bacteria in an amount of starter calculated to give a normally working, easily controlled batch.

The high counts of the pasteurised milk on the third and fourth days are probably due to much dirtier conditions of milking arising from flood conditions.

Moruya Co-operative Cheese Factory.

Micro-organisms, other than *Streptococcus lactis* (Lister), present in whey immediately after "cutting."	
Raw Milk.	Pasteurised Milk.
65,000	3,200
136,000	450
175,000	15,000
*	*
146,000	8,500
130,000	Average 6,800

* Petri dish cultures damaged.

This table presents the respective figures for the raw and "pasteurised" wheys at the time of cutting the curd. When cut, the curd surfaces liberate a small proportion of fat globules, coagulum particles and bacteria in the fast escaping and accumulating whey. While the constantly increasing volume of the whey as the result of curd shrink-

age makes bacterial counts only an index to numbers contained in the curd particles, the relative proportions of contained bacterial groups is probably similar in curd and whey at this stage.

The respective averages of 130,000 and about 7,000 per c.c. of bacteria other than *Streptococcus lactis* in the wheys from raw and pasteurised milk are striking.

Moruya Co-operative Cheese Factory.

Micro-organisms, other than *Streptococcus lactis* (Lister), present in whey at the time "running" or "wheying off."	
Raw Milk.	Pasteurised Milk.
54,500	10,900
680,000	3,500
108,000	15,000
85,000	500
*	2,500
231,800	Average 7,500†

* Cultures damaged. † Average of four.

At wheying off the contrast between the "other groups" content of the two types of whey is even more marked than at cutting. In this connection it should be borne in mind that both wheys are exposed to contamination from air, hands, mechanical stirrers, etc., which would be expected to increase their content of undesirable bacterial types.

This contamination and the different physical and chemical conditions which have been gradually taking place in the whey and curd since the time of cutting, make the bacterial count of a whey at wheying off a less reliable indication of the prevailing curd content of bacteria both as to number and to the relative proportions of groups than at cutting. Nevertheless, the marked contrast between the "raw" and "pasteurised" figures confirms the allowable deduction at

the time of cutting that the bacterial flora within the "pasteurised" curd is much superior to that within the "raw."

These figures coupled with those obtained at renneting and cutting demonstrate that the flora of curd made from pasteurised milk is remarkably free from bacteria other than *Streptococcus lactis*, and that the living members of the harmful gas-producing group are few in number. As for killed members of this group, it is probable that the pasteurisation process destroys the endo-enzymes which dissociation of the dead cells during ripening might liberate.

The first sentence of the preceding paragraph would not hold for milk pasteurised on farms—a practice being mistakenly encouraged by at least one South Coast factory. Admittedly fast batches are thus reduced in number. Farm pasteurisation entails the unevenness associated with as many processes as there are farms. Many milks are overheated with consequent changes in the milk solids, particularly the casein and mineral content, which make for a cheese of unsatisfactory body and texture. Bacterial spores will survive the processes employed, germinate and produce undesirable products; the dangers of recontamination are great. A uniformly high-grade product cannot be produced under such conditions. The practice should be compulsorily replaced by centralised pasteurisation at a factory.

Reinfection of Pasteurised Milk.

P. W. Allen[11] found that pasteurisation caused milk to become more favourable to the attack of gas-forming bacilli and *Bacillus cerogenes*. While this weakened resistance is probably general for all common forms of milk bacteria, his investigations emphasise the necessity of minimising post-pasteurisation contamination.

Pasteurised milk may be easily reinfected with undesirable bacteria by careless clearing of the cooler, pipe connections, pump, vats etc. R. S. Smith[12] and H. F. Judkins and P. A. Down[13] have drawn attention to the reinfection brought about by coolers. The latter investigators, in working with market milk, found an average increase of 3,664 bacteria per c.c. due to milk passing over a cooler, while a pump and pipe added 11,755 bacteria per c.c.; in this investigation the cooler and pipe line probably received average or better attention. Judkins and Down add that the use of chloride of lime solution in flushing out all equipment before processing milk was found to do away with practically all recontamination of milk after pasteurising.

Counts have been made of the fluid left in the bottom of vats and in the receiving trays under coolers. The lowest number of micro-organisms per c.c. was 563,000 and the highest 3,270,000. With summer conditions prevailing the numbers would be greatly increased and the proportion of harmful bacteria probably higher than in winter.

Pasteurisation and the Vitamine Content of Cheese.

Notes on the quality of a dairy product are not complete without information being given as to its vitamine content. Recent research has shown the exceptional nature of milk and many of its products as suppliers of vitamines in human nutrition. Any process which reduces the vitamine value of a foodstuff is to that extent rendered undesirable. Fortunately, as the following excerpts will show, the vitamine content of cheese made from pasteurised milk is not likely to be different in any marked way from that of the raw milk product.

The work of Steenbock, Boutwell, and Kent[14] indicates that the anti-xeropthalmic vitamine ("A" or "fat-soluble A") is destroyed by heat in the absence of water, a con-

dition not occurring in a cheese-making process. Hess and Unger,[15] writing in reference to the anti-scorbutic ("C") vitamine, state that "in connection with ageing, alkalinisation, heating and probably other agencies deleterious to this vitamine, the length of time to which it is subjected to this injurious environment is, in general, more important than the intensity of the process." Such a conclusion favours flash regenerative as against holding or vat methods of pasteurisation. Steenbock and Hart[16] state that vitamine A is a comparatively stable substance since the preparation of dried whole milk leads to little if any loss of the original value of the milk in this essential., They further state that the anti-neuritic ("B") vitamine is a very stable compound; nothing that can be done to milk, while it still preserves much of its taste and appearance, is likely to decrease the amount of this vitamine. Sterilising, drying and condensing milk do not affect the ultimate content of vitamine B. Concerning vitamine C they state that it is partly destroyed by pasteurisation, especially where the milk is agitated and aeration results . . . even the ageing of milk causes this vitamine to disappear.

It would appear that cheese made from raw or pasteurised milk may contain the anti-xerophthalmic and anti-neuritic vitamine while both are probably devoid of the anti-scorbutic vitamine.

Quality of Pasteurised Cheese.

The following notes kindly supplied by Mr. Atkinson show that an improvement in quality accompanies the improved bacterial conditions:—

"The cheeses were examined by Mr. A. T. R. Brown, a Senior Dairy Instructor of the Department of Agriculture, and Mr. H. Parbery, Manager, Moruya Co-operative Dairy Company. The cheese showed in all cases a marked improvement in flavour without losing in texture or body

to any marked extent. It was shown that cheeses could be made from pasteurised milk which were equal in texture and body to those made from raw milk. This confirms for our conditions the experience of New Zealand where more than 70% of factories use the pasteurised process. On account of the improved flavour and keeping quality since the installation of the pasteuriser at Moruya, shipping companies are buying this cheese in place of special brands previously called for."

New Zealand experience is conveniently summed up by Mr. C. Stevenson:[17]—"The improvement in the quality of the cheese made from pasteurised milk as compared with that made under the old system has been very marked indeed . . . . . in most factories where pasteurisation is carried on second grade cheese has been almost entirely eliminated . . . . with pasteurisation the milk is in practically the same condition from day to day and consequently a very much greater degree of uniformity in the quality of the cheese can be obtained."

* * * *

The writer wishes to express his appreciation of the unstinted assistance given by the manager of the Moruya Co-operative Dairy Company, Mr. Parbery, and by Mr. MacGillivray, Dairy Instructor, of this College, and the invaluable collaboration of Mr. T. H. Atkinson of the Dairy Branch.

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ABSTRACT OF PROCEEDINGS

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

MAY 3RD, 1922.

The Annual Meeting, being the four hundred and twenty-eighth General Monthly Meeting of the Society, was held at the Society's House, 5 Elizabeth Street, Sydney, at 8 p.m.

Mr. E. C. Andrews, President, in the Chair.

Sixty-seven members and four visitors were present.

The minutes of the General Monthly Meeting of the 7th December, 1921, were read and confirmed.

An apology for absence was received from His Excellency Sir Walter Davidson.

Letters were read from Mrs. Quaife and Mrs. Wallas expressing thanks for the Society's sympathy in their recent bereavements.

The Certificates of nine candidates for admission as ordinary members were read for the first time.

The Annual Financial Statement for the year ended 31st March, 1922, was submitted to members, and on the motion of Professor H. G. Chapman, seconded by Mr. C. A. Sussmilch, was unanimously adopted:—

GENERAL ACCOUNT.

Receipts.	£ s. d.	£ s. d.
To Balance, Cash on hand and at Bank, 1st April, 1921		8 8 3
„ Revenue—Subscriptions— Annual	642 12 0	
„ Rents— Offices £332 10 0		
Hall and Library 276 14 6		
	609 4 6	
„ Sundry Receipts	14 14 4	
„ Government Subsidy for 1921	399 19 10	
Total Revenue Receipts		1666 10 8
Carried forward		1666 10 8

RECEIPTS—*continued.*	£ s. d.	£ s. d.
Brought forward		1666 10 8
To Building Investment Fund—		
Balances in Savings Bank transferred ...		414 0 0
,, Balance—Union Bank of Australia Ltd.—		
Debit Balance	...1969 6 2	
Add:—Unpresented Cheque	99 14 3	
	2069 0 5	
Less:—Cash on hand...	3 0 2	
		2066 0 3
		£4154 19 2

PAYMENTS.	£ s. d.	£ s. d.	£ s. d.
By Administrative Expenditure—			
,, Salaries and Wages—			
Office Salary & Accountancy Fees	243 15 0		
Assistant Librarian	58 0 0		
Caretaker...	254 14 7		
		556 9 7	
,, Printing, Stationery, Advertising, Stamps, etc.—			
Stamps and Telegrams... ...	45 1 8		
Office Sundries, Stationery etc.	10 15 3		
Advertising	14 0 0		
Printing	56 1 10		
		125 18 9	
,, Rates, Taxes and Services—			
Electric Light	50 14 9		
Gas	14 17 2		
Insurance...	24 13 0		
Rates	159 12 6		
Telephone...	12 3 4		
		262 0 9	
,, Printing and Publishing Society's Volume—			
Printing, etc.	242 14 11		
Bookbinding	42 5 0		
		284 19 11	
,, Library—			
Books and Periodicals... ...	59 18 6		
Bookbinding	77 0 3		
		136 18	
,, Sundries—			
Centenary Celebration... ...	13 15 0		
Valuation of Society's Premises	6 6 0		
		20 1 0	
Carried forward		...1386 8 9	

PAYMENTS—*continued*	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward ...				1386	8	9			
„ Sundry Expenses—									
Repairs	5	13	7						
Lantern Operator	31	18	6						
Bank Charges	1	1	11						
Sundries	21	5	0						
Chairs	10	0	0						
Engraving Clarke Memorial Medal	0	10	0						
				70	9	0			
„ Building and Investment Fund—									
Interest on Mortgage				128	1	5			
„ Total Administrative Expenditure							1584	19	2
„ Building and Investment Fund—									
Repayment of Loan							20	0	0
Repayment of Mortgage to Australasian Association Advancement of Science ...							2300	0	0
„ Alteration to Premises—									
J. A. Dean—Payment to date ...							250	0	0
							£4154	19	2

Compiled from the Books and Accounts of the Royal Society of New South Wales, and certified to be in accordance therewith.

(Sgd.) HENRY G. CHAPMAN, M.D.,
Honorary Treasurer.

(Sgd.) W. PERCIVAL MINELL, F.C.P.A.,
Auditor.

SYDNEY, 21ST APRIL, 1922.

BUILDING INVESTMENT LOAN FUND.

STATEMENT OF RECEIPTS AND PAYMENTS, 31ST MARCH, 1922.

RECEIPTS.	£	s.	d.
To Balance, 31st March, 1921, Government Savings Bank...	274	0	0
„ Clarke Memorial Fund—Amount in respect of Commonwealth War Loan	100	0	0
„ General Fund—Repayment of Loan...	20	0	0
„ Interest—Commonwealth War Loan Government Savings Bank	20	0	0
„ Amount received from General Fund... ...	128	1	5
	£542	1	5

PAYMENTS.	£	s.	d.
By Interest paid to the Australasian Association Advancement of Science	128	1	5
„ General Fund—			
Savings Bank Balances transferred to Union Bank of Australia Ltd.	414	0	0
	£542	1	5

CLARKE MEMORIAL FUND.

BALANCE SHEET, 31ST MARCH, 1922.

LIABILITIES.	£	s.	d.	£	s.	d.	£	s.	d.
Accumulation Fund—									
Balance as at 31st March, 1921 ...				775	10	5			
Additions during the year—									
Interest, Savings Bank of N.S.W.	2	0	6						
„ Government Savings Bank	2	4	8						
„ Commonwealth Savings Bank	1	11	5						
„ Commonwealth War Loan ...	30	0	0	35	16	7	811	7	0
							£811	7	0

ASSETS.	£	s.	d.
Commonwealth War Loan...	800	0	0
Cash—Government Savings Bank...	11	7	0
	£811	7	0

STATEMENT OF RECEIPTS AND PAYMENTS, 31ST MARCH, 1921.

RECEIPTS.	£	s.	d.	£	s.	d.
To Balance 31st March, 1921.						
Savings Bank of N.S.W.	30	10	10			
Commonwealth Savings Bank ...	16	8	4			
Government Savings Bank... ...	28	11	3			
				75	10	5
„ Interest to date—						
Savings Bank of N.S.W.	2	0	6			
Government Savings Bank... ...	2	4	8			
Commonwealth Savings Bank ...	1	11	5			
Commonwealth War Loan... ...	30	0	0			
				35	16	7
				£111	7	0

PAYMENTS.	£	s.	d.
By Balance at date—			
Government Savings Bank...	11	7	0
,, Building Investment Fund—			
Amount paid in respect of Commonwealth War Loan...	100	0	0
	£111	7	0

On the motion of Mr. W. Welch, seconded by Mr. A. D. Ollé, Mr. W. P. Minell was duly elected Auditor for the current year.

It was announced that the Council had awarded the Clarke Memorial Medal to Mr. R. T. Baker, and the President then made the presentation. Mr. Baker expressed his appreciation of the Council's action in making the award.

The Annual Report of the Council was read and on the motion of Mr. R. H. Cambage was adopted:—

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR 1921-2.
(1st May to 26th April.)

The Council regret to report the loss by death of six ordinary members. Twelve members have resigned. On the other hand, thirty-one ordinary, and one honorary, members have been elected during the year.

To-day (26th April, 1922) the roll of members stands at 375.

During the Society's year there have been eight monthly meetings, ten ordinary and two special Council meetings.

Four Popular Science Lectures were given, namely:—

June 7—"Aborigines of Central Australia," by Captain S. A. White.

July 21—"The Economics of the Australian Vegetation irrespective of Timber," by H. G. Smith, F.C.S.

August 18—"Flies as Disease-Carriers," by Dr. E. W. Ferguson.

September 15—"Calculating Machinery," by G. A. Julius, B.Sc.

Meetings were held throughout the Session by the Sections of Geology, Agriculture and Industry.

Twenty-four papers were read at the Monthly Meetings and these, with a good number of exhibits, afforded much instruction and interest to members of the Society.

The Council has awarded the Clarke Memorial Medal to Mr. R. T. Baker.

CENTENARY CELEBRATIONS, 7th and 10th December, 1921: The meeting on 7th December was specially devoted to commemorating the formation in 1821, of the Philosophical Society of Australasia, the first scientific Society in Australia, and the forerunner of the Royal Society of New South Wales. Addresses partly illustrated by means of lantern slides, were delivered as follows, by speakers who had been asked to discuss subjects which were dealt with by the Philosophical Society of Australasia:—

Astronomy—Professor W. E. Cooke, M.A., F.R.A.S.
Anthropology—Charles Hedley, F.L.S.
Botany—J. H. Maiden, I.S.O., F.R.S.
Geology—Sir Edgeworth David, K.B.E., C.M.G., D.S.O., D.Sc., F.R.S.
Early Records—J. F. Watson, M.B., Ch.M.
Biographical Sketches—R. H. Cambage, F.L.S.

On Saturday, 10th December, 1921, in order to further celebrate the occasion, the President and members attended at Kurnell, to visit the spot where the President and Members of the Philosophical Society of Australasia erected a brass tablet in memory of the landing of James Cook and Joseph Banks.

Addresses suitable to the occasion were delivered by the President, Mr. E. C. Andrews, Sir William Cullen, K.C.M.G.,

LL.D., Chief Justice of New South Wales and Chancellor of the University of Sydney, The Hon. Sir Joseph Carruthers, K.C.M.G., M.L.C., LL.D., His Honour Judge E. B. Docker, M.A., and the Hon. J. Lane Mullins, M.A., M.L.C.

The classification and indexing of the large collection of German University dissertations occupied a considerable amount of time during the year, but the work is now completed and the set, comprising about 80 volumes, is ready for binding.

In December last, Mr. J. H. Maiden generously presented to the library Parts 1 to 13 (1824–1849) of Augustin De Candolle's "Prodromus systematis naturalis regni vegetabilis" together with volumes 1 to 4 of Alphonse and Anne De Candolle's "Monographiæ Phanerogamarum." A complete set of the Prodromus comprises 17 parts, and it is suggested that the Society should endeavour to secure the remaining four parts, together with Buek's Index to the Prodromus (4 vols.), and so complete this famous work on systematic botany. If the remaining five volumes of the Monographiæ could also be obtained it would much enhance the value of the botany section of the library.

The number of unbound volumes of periodicals is being steadily reduced, 288 volumes being bound during the year at a cost of £91/16/0, and a further sum of £100 has been set aside for the continuation of binding during the current year.

The Commonwealth Government having during the year 1921, removed restrictions on the receipt of scientific books from enemy countries, invitations to resume exchanges were sent from the Society to 72 German and Austrian Scientific Institutions on the exchange list before the war. Up to date answers have been received from twenty-eight societies, twenty-six have accepted the invitation, while

two have not resumed publication owing to high cost of material.

The donations to the library have been as follows:—55 volumes, 1694 parts, 56 reports, 1 catalogue and 3 calendars.

The alterations in connection with the building, now in progress, will necessitate the re-arranging of the whole of the contents of the library, and it is hoped that the additional shelf space intended to be made available will be sufficient to meet the needs of the library for some years to come.

* * * * *

It was announced that the following members had died during the recess:—Dr. F. H. Quaife and Mr. T. I. Wallas.

The following donations were laid upon the table:—4 volumes, 95 parts, 11 reports and 1 map.

The President, Mr. E. C. Andrews, then delivered his address.

There being no other nominations, the President declared the following gentlemen to be officers and Council for the coming year:—

President:

C. A. SUSSMILCH, F.G.S.

Vice-Presidents:

W. S. DUN.
Prof. C. E. FAWSITT, D.Sc., Ph.D.
J. NANGLE, O.B.E., F.R.A.S.
E. C. ANDREWS, B.A., F.G.S.

Hon. Treasurer:

Prof. H. G. CHAPMAN, M.D.

Hon. Secretaries:

R. H. CAMBAGE, F.L.S.
J. A. POLLOCK, D.Sc., F.R.S.

Members of Council:

C. ANDERSON, M.A., D.Sc.
Prof. Sir EDGEWORTH DAVID, K.B.E., C.M.G., D.S.O., F.R.S., D.Sc.
R. GREIG-SMITH, D.Sc., M.Sc.
T. H. HOUGHTON, M. INST. C.E.
J. H. MAIDEN, I.S.O., F.R.S., F.L.S.
Prof. J. READ, M.A., PH.D., B.Sc.
H. G. SMITH, F.C.S.
Prof. J. DOUGLAS STEWART, B.V.Sc., M.R.C.V.S.
Assoc.-Prof. O. U. VONWILLER, B.Sc.
Prof. R. D. WATT, M.A., B.Sc.

The out-going President then installed Mr. C. A. Sussmilch as President for the ensuing year, and the latter briefly returned thanks.

On the motion of Dr. Cotton, seconded by Dr. A. B. Walkom, a hearty vote of thanks was accorded to the retiring President for his valuable address.

Mr. Andrews briefly acknowledged the compliment.

JUNE 7TH, 1922.

The four hundred and twenty-ninth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. C. A. Sussmilch, President, in the Chair.

Thirty-four members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The President announced the deaths of Dr. A. Lang McLean, elected in 1917, and Professor J. A. Pollock, Honorary Secretary, elected a member in 1887.

The President also announced that the following resolution had been passed by the Council:—

"Members of the Council of the Royal Society of New South Wales desire to place on record their profound sorrow at the death of their dear collegue Professor J. A. Pollock, and to express their high appreciation of his eminent service in the cause of science, and of his personal, most valuable, and unselfish work for this Society, and also to express their deep sympathy with Miss Pollock in her sad loss."

Letters were received from Mrs. A. L. McLean and Miss Pollock expressing thanks for the Society's sympathy in their recent bereavements.

The certificates of ten candidates for admission as ordinary members were read for the second time.

Messrs. G. Inglis Hudson and G. Hooper were appointed Scrutineers and Dr. R. Greig-Smith deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—John Job Crew Bradfield, Patrick Brough, Andrew Ferguson, William Arthur Greig, Ernest Godfried Jacobs, William George Jira, Alexander Clarke MacKay, John McLuckie, Thomas Hodge Smith and Harry Clement Whibley.

The President announced that Mr. H. G. Smith had been awarded the David Syme Medal and Prize.

The President announced that a Popular Science Lecture entitled:—"The Development of Forestry in New South Wales," would be delivered by Mr. R. T. Dalrymple-Hay, L.S., on Thursday, 15th June, 1922.

The following donations were laid upon the table:—73 parts, 9 volumes and 5 reports.

THE FOLLOWING PAPERS WERE READ:

1. "The Position of the Double Linkage in Piperitone, Part II," with notes on some of the Derivatives," by A. R. Penfold, F.C.S. Remarks were made by Mr. R. W. Challinor.

2. "The Incidence of Anthrax in Stock in Australia," by Max Henry, D.S.O., B.V.Sc., M.R.C.V.S., which in his absence was read by Prof. J. Douglas Stewart.

3. "Notes on the species of the genera *Darwinia Homoranthus* and *Rylestonea* in New South Wales, Queensland and South Australia," by Edwin Cheel. Remarks were made by Mr. R. T. Baker.

4. "Notes on *Melaleuca linariifolia* Sm. and *M. trichostachya* Lindl.," by Edwin Cheel.

EXHIBIT:

The right- and left-handed forms of piperitone and some new crystalline derivatives of inactive piperitone, by Prof. J. Read, and Mr. H. G. Smith.

A short explanatory account of the specimens was given by Professor Read.

JULY 5TH, 1922.

The four hundred and thirtieth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. C. A. Sussmilch, President, in the Chair.

Forty-one members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The President extended a cordial welcome to Dr. Robert Trumpler, Assistant Astronomer, Lick Observatory, who was passing through Sydney on his way to Western Australia for the purpose of observing the solar eclipse on the 21st September, 1922.

The certificates of two candidates for admission as ordinary members were read for the first time.

The President announced that portraits of the late H. D. Walsh, B.A.I., a past President, and of the late Lawrence Hargrave had been presented to the Society and hung in the Society's Hall.

The President announced that Acting-Professor O. U. Vonwiller had been elected Honorary Secretary in place of the late Professor J. A. Pollock, and Charles Hedley elected to fill the consequent vacancy on the Council.

The President announced that a Popular Science Lecture entitled:—"The Races of the World—their Migrations

and Status," would be delivered by Professor T. Griffith Taylor, D.Sc., on Thursday, 20th July, 1922.

The following donations were laid upon the table:—76 parts and 6 volumes.

THE FOLLOWING PAPERS WERE READ:

1. "Observations respecting some Essential Oils from *Leptospermum Liversidgei*," by A. R. Penfold, F.C.S. Remarks were made by Messrs. A. A. Hamilton, E. Cheel, M. B. Welch, and H. G. Smith.
2. "Preliminary Note on a new Stearoptene (probably a phenol ether) occurring in some Essential Oils of the Myrtaceæ," by A. R. Penfold, F.C.S. and F. R. Morrison.
3. "A Chemical and Bacteriological Study of a typical wheat soil of New South Wales," by J. K. Taylor, B.Sc. (Agr.), which in his absence was read by Mr. G. Wright.

The President, Mr. C. A. Sussmilch, delivered an interesting lecturette on "Scientific problems of the Pacific, Part I—Geography." This was the first of a series of lecturettes to be delivered by various members on subjects connected with the Pacific, and which have been inaugurated in view of the fact that it has been decided to hold the Pan-Pacific Science Congress in Australia in 1923.

AUGUST 2ND, 1922.

The four hundred and thirty-first General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. C. A. Sussmilch, President, in the Chair.

Forty-three members were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of three candidates for admission as ordinary members were read: two for the second, and one for the first time.

Professor J. Read and Dr. C. Anderson were appointed Scrutineers, and Mr. J. Nangle deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society: Arthur Edward Mills and Frank Richard Morrison.

The President announced the death of Mr. J. E. Carne, (a Clarke Medallist 1920) who was elected a member in 1909.

A letter was read from Mrs. Carne expressing thanks for the Society's sympathy in her recent bereavement.

The President announced that on the evening of the 5th August, the Royal Society, in conjunction with the University, had entertained Dr. William W. Campbell, Director of the Lick Observatory, and other scientists from the United States of America and from New Zealand, who were visiting Australia for the purpose of viewing the solar eclipse on the 21st September, 1922.

The President announced that a Popular Science Lecture entitled:—"Solar Eclipses—with special reference to the eclipse which will take place in September next," would be delivered by Mr. J. Nangle, O.B.E., F.R.A.S., on Thursday, 17th August, 1922.

The following donations were laid upon the table:—7 volumes, and 86 parts.

THE FOLLOWING PAPERS WERE READ:

1. "The Miscibility Test for Eucalyptus Oils," by Prof. C. E. Fawsitt, D.Sc., Ph.D, and C. H. Fischer. Remarks were made by Messrs. A. R. Penfold and R. W. Challinor.

2. "On the Australian Melaleucas and their Essential Oils," Part VI., by R. T. Baker and H. G. Smith, F.C.S. Remarks were made by Mr. M. B. Welch.

3. "The Essential Oil of *Backhousia myrtifolia*," Part I., by A. R. Penfold, F.C.S.

Mr. E. C. Andrews, delivered an interesting Lecturette on Scientific Problems of the Pacific, Part II—Geology. This was the second of a series of lecturettes to be delivered by various members on subjects connected with the Pacific.

EXHIBIT:

Mr. J. Nangle, exhibited for Mr. H. J. Swain, a Coelostat made at the Sydney Technical College for the University Party at the forthcoming Eclipse in September next.

SEPTEMBER 6TH, 1922.

The four hundred and thirty-second General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. C. A. Sussmilch, President, in the Chair.

Forty-nine members and five visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of five candidates for admission as ordinary members were read: one for the second and four for the first time.

Messrs. M. B. Welch and G. Inglis Hudson were appointed Scrutineers, and Mr. E. C. Andrews deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society: Harold George Raggatt.

The President announced that the alterations to the Building had been completed, and a hearty vote of thanks

was accorded to Mr. H. C. Kent, Honorary Architect, for his kindness in supervising the work.

The President announced the deaths of Mr. A. H. Belfield and Mr. W. G. Jira.

A letter was read from Mr. A. L. Belfield expressing thanks for the sympathy extended to his family in the death of his father, Mr. A. H. Belfield.

The President announced that a Popular Science Lecture entitled:—"The Duck-billed Platypus," would be delivered by Acting-Professor L. Harrison, B.Sc., B.A., on Thursday, 21st September, 1922.

The following donations were laid upon the table:—126 parts, 3 volumes and 3 reports.

THE FOLLOWING PAPERS WERE READ:

1. "Acacia Seedlings," Part VIII, by R. H. Cambage, F.L.S. Remarks were made by Sir Edgeworth David and Mr. E. C. Andrews.
2. "Note on the Relationship between Oil Glands and Oil Yields in the Eucalyptus," by M. B. Welch, B.Sc.
3. "Poisoning of Sheep by *Solanum cinereum*," by Sydney Dodd, F.R.C.V.S., D.V.Sc. Remarks were made by Mr. J. H. Maiden and Judge Docker.

An interesting lecturette was given by Mr. J. Nangle, O.B.E., F.R.A.S., on "The Solar Eclipse of the 21st September, 1922."

EXHIBIT:

Mr. G. Hooper exhibited portion of an Aboriginal Grave Tree from Gilgandra and now in the Technological Museum.

OCTOBER 4TH, 1922.

The four hundred and thirty-third General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. C. A. Sussmilch, President, in the Chair.

Thirty-nine members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The President announced the death of Mr. C. O. Hamblin, who was elected a member in 1919, and was one of the Honorary Secretaries of the Section of Agriculture.

The certificates of five candidates for admission as ordinary members were read: four for the second, and one for the first time.

Messrs. A. D. Ollé and H. V. Bettley-Cooke were appointed Scrutineers, and Dr. C. Anderson deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society: Edward Patrick Fleming, Robert Grant, Harold Arthur Montague Sandy and Blair Anderson Wark.

The following donations were laid upon the table:—73 parts and 1 volume.

THE FOLLOWING PAPERS WERE READ:

1. "On the occurrence of l-Phellandrene in the Oil of *Melaleuca acuminata*, of South Australia," by H. G. Smith, F.C.S.
2. "The Essential Oils of two Leptospermums," by A. R. Penfold, F.C.S. Remarks were made by Messrs. E. Cheel, A. D. Ollé, R. W. Challinor and Professor Vonwiller.

Professor L. A. Cotton, delivered an interesting Lecturette on "Scientific Problems of the Pacific, Part III—Vulcanology and Seismology." This was the third of a series of Lecturettes to be delivered by various members on subjects connected with the Pacific.

EXHIBIT:

Mr. E. H. Booth exhibited an interesting series of photographs illustrating the total solar eclipse of 21st September, 1922.

NOVEMBER 1ST, 1922.

The four hundred and thirty-fourth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. C. A. Sussmilch, President, in the Chair.

Forty-eight members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificate of one candidate for admission as an ordinary member was read for the second time.

Messrs. A. J. Cresswick and E. G. Jacobs were appointed Scrutineers, and Professor O. U. Vonwiller deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society: Maurice Campana.

The following donations were laid upon the table:—2 volumes, 113 parts and 3 reports.

THE FOLLOWING PAPERS WERE READ:

1. "The Stereoisomeric Forms of Menthone," by R. S. Hughesdon, H. G. Smith, F.C.S., and John Read, M.A., Ph.D., B.Sc.
2. "A Contribution to the Chemistry of the Phellandrenes," by E. Hurst, H. G. Smith, F.C.S., and John Read, M.A., Ph.D., B.Sc. Remarks were made by Professor Fawsitt.
3. "Notes on the Chemistry of certain Australian Plant Products, Part I," by H. G. Smith, F.C.S. Remarks were made by Messrs. J. H. Maiden, R. H. Cambage and E. Cheel.

4. "Notes on Plate Exposures and the subsequent Photographic Treatment adopted by the Sydney University Eclipse Expedition," by Edgar H. Booth, B.Sc. Remarks were made by Prof. Vonwiller and Mr. J. Nangle.

5. "The Essential Oils of two species of Homoranthus and the Occurrence of Ocimene," by A. R. Penfold, F.C.S. Remarks were made by Mr. R. W. Challinor.

6. "The Essential Oil of *Kunzea corifolia*," by F. R. Morrison. Remarks were made by Mr. J. H. Maiden.

7. "Notes on the Food Value of the Snapper and on the Constants of Whale Oil," by W. M. Doherty, F.I.C., F.C.S. Remarks were made by Dr. H. S. H. Wardlaw.

EXHIBITS:

1. Photograph of a remarkable injury to an Ironbark tree probably the result of lightning (the injury extends to the ultimate branchlets). Taken by Mr. J. E. Young, Barakula, near Chinchilla, Queensland. By J. H. Maiden.

2. Photograph of an Ironbark tree also struck by lightning. By R. Grant.

3. Upper Marine Sandstone Permo-Carboniferous, from Jervis Bay, containing fossils of *Spirifera tasmaniensis*, and *Spirifera vespertilio*, also *Martiniopsis*, by A. D. Ollé.

DECEMBER 6TH, 1922.

The four hundred and thirty-fifth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. C. A. Sussmilch, President, in the Chair.

Forty-one members and three visitors were present.

The President announced the death of the Hon. Dugald Thomson, who was elected a member in 1878.

The certificate of one candidate for admission as an ordinary member was read for the first time.

A letter was read from Mrs. C. O. Hamblin, expressing thanks for the Society's sympathy in her recent bereavement.

The following donations were laid upon the table:—8 volumes, 116 parts and 4 reports.

THE FOLLOWING PAPERS WERE READ:

1. "Notes on Hornblende and Bytownite from Hypersthene Gabbro, Black Buff, near Broken Hill," by Miss Ida A. Brown, B.Sc., (communicated by W. R. Browne, D.Sc.).
2. "The Economic Utilisation of the Residues from the Steam Rectification of the Essential Oil of *Eucalyptus cneorifolia* and the Germicidal Values of the Pure 'Active' Constituents," by A. R. Penfold, F.C.S., and R. Grant, F.C.S. Remarks were made by Mr. R. W. Challinor.
3. "The Essential Oil of *Eriostemon Crowei* (*Crowea saligna*) and the presence of a new Phenol Ether," by A. R. Penfold, F.C.S., and F. R. Morrison.
4. "The Resinous Exudation of Rosewood," by M. B. Welch, B.Sc., A.I.C. Remarks were made by Messrs. J. H. Maiden and R. T. Baker.
5. "A Method of Identification of some Hardwoods," by M. B. Welch, B.Sc., A.I.C.
6. "Notes on the Occurrence of Gastrioceras, at the Irwin River Coal-Field, W.A., and a comparison with the so-called Paralegoceras from Letti, Dutch East Indies," by W. S. Dun, and Sir Edgeworth David, K.B.E., D.S.O., C.M.G., D.Sc., F.R.S.
7. "The Glucoside occurring in the timber of the "Red Ash" *Alphitonia excelsa*, Reiss," by H. G. Smith, F.C.S. and John Read, M.A., Ph.D., B.Sc.

8. "On an Olivine-bearing Quartz-Monzonite from Kiandra, N.S.W." by W. R. Browne, D.Sc., and W. A. Greig.

9. "Note on the Occurrence of Calcite in a Basalt from the Maitland District, N.S.W.," by W. R. Browne, D.Sc.

10. "Notes on the Bacteriological Aspect of Pasteurisation of Milk for Cheddar Cheese-making," by J. K. Murray, B.A., B.Sc., (communicated by R. D. Watt, M.A., B.Sc.)

EXHIBITS:

1. Professor Sir Edgeworth David exhibited specimens of spore-bearing chert from a horizon in the Lower Marine Stage of the Permian (Permo-Carboniferous) on the Eelah Road, Portion 29, Parish Middlehope, County Durham. The spores are in a very perfect state of preservation, the cuticle retaining the original structure. It is suggested that the surrounding hills of Carboniferous sediments and eruptives—a continuation of the Hudson's Peak area—during the time of Lower Marine sedimentation supported a coniferous (Araucarian) forest the transported spores of which became imbedded and preserved in the fine grained sediments.

2. Professor W. E. Cooke, Government Astronomer, a record of the Chilian Earthquake of the 11th November, 1922.

GEOLOGICAL SECTION.

ABSTRACT OF THE PROCEEDINGS

OF THE

GEOLOGICAL SECTION.

Ten meetings of the Section were held during the year.

The average attendance was fourteen members and five visitors.

Monthly Meeting, 20th March, 1922.

Professor Sir Edgeworth David in the Chair.

Twelve members and three visitors were present.

Professor David was re-elected Chairman for the year, and Professor L. A. Cotton and Mr. W. R. Browne were elected joint Honorary Secretaries.

EXHIBITS:

1. By Mr. Harper—Maps and specimens illustrating the occurrence, near the proposed Avon Dam, of small inliers of Chocolate Shale in Hawkesbury Sandstone, indicating a slight unconformity between the Hawkesbury and Narrabeen stages, also specimens of a volcanic breccia occurring in places between the sandstone and the Narrabeen Shales, and of tuffs containing fragments of the underlying chocolate shale.

2. From the Mining Museum—(*a*) Specimens illustrating the occurrence and association of mica in the Macdonnell Ranges; (*b*) a portion of what appeared to be a mass of angular quartz fragments cemented by iron oxide, the whole assuming a globular shape; (*c*) a specimen of naumannite (selenide of silver) from the Lady Fanny Mine, Queensland.

3. From the Australian Museum—(*a*) Ruby-margarite rock, from Rimu, Hokatika, New Zealand; (*b*) specimens of analcite, prehnite, and natrolite occurring in cavities in volcanic breccia associated with basalt at Ardglen.

4. By Professor Cotton—Specimens of (*a*) the rock rodingite from near Nelson, New Zealand; and (*b*) the Maitai slates, New Zealand.

5. By Mr. Browne—(*a*) Hornblende lamprophyre from a dyke intersecting the granite near Pretty Point, Kosciusko Plateau; (*b*) a series of specimens from Cooma illustrating what is believed to be a gradation from slate through phyllite to mica-schist.

6. By Professor David—(*a*) Specimens of Upper Devonian rocks from Victoria; (*b*) Ice-scratched boulders from the Kosciusko region and from Gormanstown (Tasmania), of Pleistocene age; (*c*) contemporaneously-contorted varve-rock of Pleistocene age, from near Mount Lyell, Tasmania.

The Chairman gave an address, illustrated by lantern slides, on the geological features of certain parts of Tasmania, with special reference to the evidence of the Pleistocene glaciation.

Monthly Meeting, 24th April, 1922.

Professor Sir Edgeworth David in the Chair.

Sixteen members and one visitor were present.

EXHIBITS:

1. By Mr. Osborne—(*a*) Silicified rock from Kiama; (*b*) Jasper from Nundle district; (*c*) Pyroxenite from Nundle district.

2. By Dr. Cotton—Sample of petroleum and country rock from Murchison district, New Zealand.

3. By Mr. Poole—Photographs of the Sounds about Picton and Nelson, New Zealand; also of river gravels near Blenheim.

Dr. Daněs gave an illustrated lecture dealing with limestone physiography and hydrography in Australia, with special reference to the Northern Territory and Queensland. Two great deposits of limestone were recognised, one of Cambrian and the other of Cretaceous age. The underground water supply in the limestones contributes largely to the flow of the Roper, Gregory and other northern rivers.

Remarks were made by Professor Taylor, Mr. Andrews, Judge Docker, Mr. Poole and the Chairman.

Monthly Meeting, 15th May, 1922.

Mr. E. C. Andrews in the Chair.

Fourteen members and five visitors were present.

A large collection of fossils from Wandrawandian Creek was exhibited by Mr. Varney Parkes, and the place of occurrence illustrated by a large drawing representing the cliff-face and horizontal strata in which the fossils were found. Remarks were made by Messrs. Browne and Dun, and the Chairman.

Professor Taylor gave a lantern lecture on the glacial physiography of the Kosciusko region, with special reference to the recent discoveries made by him and his party, including Mr. Browne and Mr. F. Jardine. Remarks were made by Messrs. Browne, Jardine and Andrews, and Dr. Cotton.

Monthly Meeting, 19th June, 1922.

Mr. E. C. Andrews in the Chair.

Sixteen members and twelve visitors were present.

EXHIBITS:

1. By Dr. Anderson—Lower jaw of a diprotodont from near Scone.

2. By Mr. W. R. Browne—Specimens lent by the Mining Museum, comprising: (*a*) Photos of a tuff-cone at Auckland, N.Z.; (*b*) a polished rock, possibly a varve-rock, showing miniature faulting, from Pokolbin, N.S.W.; (*c*) clear calcite from the Garabaldi Mine, Lionsville; (*d*) calcareous concretion forming cup-and-ball structure; (*e*) Polished boulder from the Maitland district.

The origin of the polish on this last exhibit was the subject of much discussion.

Mr. Halligan gave a lecture on his recent aeroplane flight over Lake Eyre, illustrated by slides from original photographs taken from the air. Remarks were made by Mr. Andrews, Professor Taylor and Dr. Woolnough.

Monthly Meeting, 17th July, 1922.

Professor Sir Edgeworth David in the Chair.

Eleven members and seven visitors were present.

Specimens of rocks showing natural polish were exhibited, and a discussion on the subject of Desert Polish was opened by Dr. Woolnough, the other speakers being Dr. Daněs, Messrs. Parkes, Browne, and Andrews, Professor Taylor, Mr. Dun and the Chairman.

A discussion of Professor Taylor's lecture on the Physiography of the Kosciusko Plateau was initiated by Mr. Andrews and contributed to by Judge Docker, Mr. Browne and the Chairman.

Monthly Meeting, 28th August, 1922.

Professor Sir Edgeworth David in the Chair.

Twelve members and two visitors were present.

EXHIBITS:

By Judge Docker—Stereoscopic views illustrating the Narrabeen beds.

Mr. Harper opened a discussion on the relationships of the Narrabeen and Hawkesbury beds, with special reference to an apparent unconformity exposed recently at the foundations excavated for the Avon Dam.

The subject was spoken to by Mr. E. C. Andrews, Judge Docker, Dr. W. R. Browne, Dr. L. A. Cotton, Messrs. T. L. Willan and H. G. Raggatt, and the Chairman. Mr. Harper then replied.

Monthly Meeting, 18th September, 1922.

Professor Sir Edgeworth David in the Chair.

Sixteen members and seven visitors were present.

EXHIBITS:

1. By Mr. Halligan—Pebbles from Lake Eyre region showing a varnish-like polish.

2. By Mr. L. L. Waterhouse—Suite of specimens illustrating the geology of King and Flinder's Islands, Bass Straits.

3. By Mr. Smith—(*a*) Beryl from Torrington; (*b*) Monazite from Cow Flat, Deepwater.

A lantern lecture was given by Professor David on the Geological History of Bass Straits.

Monthly Meeting, 16th October, 1922.

Professor Sir Edgeworth David in the Chair.

Fourteen members and four visitors were present.

EXHIBITS:

1. By Mr. Waterhouse—(*a*) An unknown mineral, believed to be a pseudomorph, possibly after gypsum, and containing carbonates of Mn, Zn, Fe, Ca, and Ba, with a coating of native Cu; (*b*) a collection of four aboriginal tomahawks from Galston, near Hornsby.

2. By Mr. Dun—An example of cone-in-cone structure (the property of Professor Taylor) from 200 miles north of

Bourke, showing a semi-botryoidal structure at the base of the cones.

3. By the Chairman—Specimens, lent by the National Herbarium, of the foliage of the Celery-topped Pine from Tasmania, also a fossil example of the same from the Rose Valley Deep Lead, Emmaville.

Judge Docker gave a talk, illustrated by specimens and lantern views, on certain rock-structures observed by him along the coast of New South Wales, in the Blue Mountains, and in Victoria. These structures, it was suggested, might represent portions of fossil trees. Remarks were made by Professor David and Mr. Andrews.

The Chairman gave a *resumé* of his lecture on the geological history of Bass Straits delivered at the preceding meeting, and this was discussed by Mr. Andrews.

Monthly Meeting, 20th November, 1922.

Professor Sir Edgeworth David in the Chair.

Fourteen members and nine visitors were present.

EXHIBITS:

1. By Dr. Browne—A book of coloured photographs illustrating agates from various parts of the world, and particularly from the Clent Hills, N.Z.

2. By Mr. L. L. Waterhouse—A specimen from the Yuanmi Mine, W.A., presented to the University by Mr. McKern, B.E., and showing metasomatic replacement of jasper by pyrites.

3. By Judge Docker—Ironstone concretions resembling plant remains.

4. By Professor David—Chert with sporangia, both macrospores and microspores being present, from a horizon about 2000 feet below the Greta coal-measures. The specimen was collected near Belah, in the Maitland district.

A lecture was given by Dr. Daněs on "The New Views about the Tectonics of the European Mountains." Dr. Daněs pointed out that in a number of cases the structures could be explained by simple faulting rather than by overfolds and pronounced overthrust movements.

Monthly Meeting, 18th December, 1922.

Mr. W. S. Dun in the Chair.

Thirteen members and three visitors were present.

EXHIBITS:

1. By Dr. Browne—Specimens of the Saddleback Dolerite from Port Kembla, four types showing progressive stages of albitisation and kaolinisation.

2. By Mr. E. C. Andrews—A series of photographs of corals, sea-anemones, fossil wood and agate, lent by Mr. Dick of Port Macquarie.

3. By Mr. Mitchell—Trilobites and fossil insects from various localities.

4. By Mr. W. S. Dun—*Glossopteris* and *Vertebraria* from near Oaklands Railway Station, Riverina District.

5. By Judge Docker—Lantern slides illustrating ironstone concretions resembling fossil trees.

A lantern lecture was given by Mr. Mitchell illustrating his work on the trilobites of the Yass-Bowning district, and on the fossil insects of the Newcastle district. Remarks were made by the Chairman.

SECTION OF AGRICULTURE.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF AGRICULTURE.

May 22nd, 1922.

The Annual Meeting, being the sixth Annual Meeting of the Section, was held at the Society's House, Sydney, at 8 p.m.

Professor R. D. Watt in the Chair.

The minutes of the last general meeting were confirmed.

The report of the Committee to further investigate the question of "Fecundity in Fowls," stated that Principal Southee had planned a series of investigations into the question, and, as far as the Section was concerned, it was decided to leave the matter entirely in his hands. This report was adopted.

The Chairman drew attention to the fact that the Section had no definite rule to follow, in regard to the number of its office-bearers.

The meeting decided to limit the office-bearers to a Chairman, one Vice-Chairman, two Honorary Secretaries, and four members of Committee.

The Annual election of office-bearers resulted as follows: Chairman—Professor R. D. Watt, M.A., B.Sc. Vice-Chairman—Professor J. D. Stewart, B.V.Sc., M.R.C.V.S. Honorary Secretaries—P. Hindmarsh, M.A., B.Sc. Agr., C. O. Hamblin, B.Sc., B.Sc. Agr. Committee—S. Dodd, D.V.Sc., F.R.C.V.S., A. D. Ollé, F.C.S., E. A. Southee, O.B.E., M.A., B.Sc. Agr., F.L.S., W. L. Waterhouse, M.C., B.Sc., Agr. D.I.C.

The Chairman delivered an address upon "Recent Researches connected with the Soil."

Despite the war, progress in all European countries had been made in soil research. Important papers had been put forward in England and United States and even Japan. Australia has taken a rather insignificant part in the work of soil research.

Australia stands greatly in need of a systematic soil survey. The more complete our knowledge of the soil, the more possible it becomes to evolve a rational system of agriculture. Stress was laid upon the following recent researches:—(*a*) the colloidal form of certain soil constituents, and the effect of this form. (*b*) Soil acidity and the lime requirements of soils and their determination. (*c*) Artificial humus and artificial farmyard manure. (*d*) The examination of water extracts of the soil. (*e*) The living organisms of the Soil.

June 12th, 1922.

Professor R. D. Watt in the Chair.

Mr. H. Wenholz, B.Sc. Agr., addressed the meeting upon "A New Viewpoint on the Liming of Soils." The speaker after reviewing the accepted reasons for the liming of soils discussed their value. He pointed out that with our main crops, the application of lime is not beneficial, and is apparently unprofitable, and possibly should be used with caution on other crops. Touching upon the generally accepted belief that a soil containing less than one per cent. of carbonate of lime requires liming, Mr. Wenholz expressed the belief that it was an unjustifiable assumption to apply to New South Wales soils. After discussing the question of acid tolerant crops, the speaker said the present position calls for caution as regard theories and recommendations concerning the use of lime, until more accurate data, and the results of field experiments are available.

July 10th, 1922.

Professor R. D. Watt in the Chair.

The Secretary presented on behalf of Mr. J. K. Taylor, B.Sc. Agr., an exhibit showing the mechanical analysis of a Wagga soil. Accompanying it was a note by Mr. Taylor upon the "Mechanical Analysis of a Soil." Mr. Taylor described a method whereby the finer soil samples after sieving, instead of being separated into two fractions by the Schultz elutriator method, were further subdivided by the application of Hall's beaker method.

Mr. J. K. Taylor's paper upon "A Chemical and Bacteriological Study of a Typical Wheat Soil of New South Wales" which had been read in abstract at the general meeting of the Royal Society, was then read in detail.

August 14th, 1922.

Professor R. D. Watt in the Chair.

Mr. Max Henry, B.V.Sc., M.R.C.V.S., read a paper upon the "Economic Aspects of Meat Inspection." The primary and essential function of meat inspection was to protect the consuming public. Attention was paid to the legal aspect of the subject. The various acts if enforced would result in a large amount of unjustifiable waste. Meat inspection in Australia needed to be placed upon a basis more in line with modern knowledge.

September 11th, 1922.

Professor J. D. Stewart, in the Chair.

Mr. W. L. Waterhouse exhibited some wheat crosses, which were particularly interesting as illustrating inheritance upon Mendelian lines.

Mr. A. J. Nicholson, M.Sc., addressed the meeting upon the "Teaching and Practice of Entomology in the United

States of America." He stressed the lead of the United States of America in Entomology. He outlined the system there in vogue and methods of attack upon outbreaks of insect pests.

October 9th, 1922.

Professor R. D. Watt, in the Chair.

The Chairman communicated the news of the death of one of the Honorary Secretaries of the Section, Mr. C. O. Hamblin, B.Sc., B.Sc. Agr. He drew attention to his qualities as a scholar, a soldier, and a man. He spoke concerning Mr. Hamblin's brilliant record at the University, where he gained particular distinction along the biological side. Upon Mr. Hamblin's return from active service abroad with the Australian Expeditionary Force, he took up work as assistant plant pathologist. His work was full of promise and some achievement.

The Chairman moved the following motion, which was carried, that—

"The Agricultural Section of the Royal Society of New South Wales desires to place on record its appreciation of the valuable services of the late Mr. C. O. Hamblin, B.Sc., B.Sc. Agr., one of its Honorary Secretaries, to express its sincere regret at his untimely death and to tender a message of loving sympathy to his bereaved relatives."

Mr. W. L. Waterhouse exhibited a sectorial chimera in lamb's tongue. Also a photograph showing grass tufts occurring in a wheat cross (Canberra—Thew). There were 57 tufts out of 366 plants. He mentioned that the tufts also occur in other crosses notably Jonathan × Indian F. In this latter case all were sterile. Also an exhibit of golden grain barley showing head smut (*Ustilago hordei.*)

Mr. J. K. Murray, B.A., B.Sc., N.D.D., gave a lantern lecture upon the "Bacteriological Aspect of the Pasteurisation of Milk for Cheese-making.

November 13th, 1922.

Professor J. D. Stewart, in the Chair.

Professor R. D. Watt, M.A., B.Sc., delivered an address upon his visit, as member of the Expert Committee to the Murray irrigation and dry areas. Professor Watt said the land north of the Murray, would carry large numbers of prosperous irrigationists and dry farmers, if irrigation, bridges, and water were provided. He showed how the mallee country of Victoria had been developed into progressive wheat lands with only a 12 inch rainfall, and how in the Nine Mile and Benanee areas the land and rainfall were equally favourable for their development.

December 11th, 1922.

Professor R. D. Watt, in the Chair.

Principal Southee exhibited photographs of 'Potato Leaf Curl.' This occurred in the areas at the Hawkesbury College devoted to experiments upon tuber unit selection of potatoes for high yielding and disease-free strains.

Mr. G. Wright exhibited a set of colour standards for determining hydrogen ion concentrations.

Mr. A. H. E. MacDonald spoke upon "Our Unused Coastal Lands." After outlining the history of the North Coast lands, the speaker pointed out the amount of fair agricultural land available for more intensive use, particularly the valley of the Upper Clarence. Further north very large areas of similar lands existed. Production was being stifled due to (*a*) land being used for purposes that would not give the best return per acre, probably due to bad means of communication; (*b*) lack of skill, capital, and knowledge upon the part of the owner; (*c*) lack of desire on the part of the owner.

Committee Meetings—Seven Committee meetings were held during the year. The following attendances were recorded:—Professor Watt 6, Professor Stewart 3, Mr. C. O. Hamblin 3, Mr. P. Hindmarsh 7, Dr. S. Dodd 2, Mr. A. D. Ollé 7, Principal Southee 5, Mr. W. L. Waterhouse 5.

SECTION OF INDUSTRY.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF INDUSTRY.

Monthly Meeting, 21st June, 1922.

Mr. J. E. Bishop in the Chair.

The following Sectional Officers were elected for the Session:—Chairman, Mr. Robert Vicars; Hon. Secretary, Dr. R. Greig-Smith; Committee, Messrs. J. E. Bishop, E. T. Fisk and A. B. Hector, Past Chairmen; H. V. Bettley-Cooke, R. H. Challinor, F. A. Coombs, W. W. L'Estrange, J. C. McDowall, A. D. Ollé, and W. Poole.

Mr. D. S. J. Harricks, M.I.E. Aust., of the Colonial Sugar Refining Co., gave a lecture upon "Sugar and its Manufacture," in which he traced the processes from the cane-field to the mill and finally to the refinery, illustrating by means of lantern slides many of the engineering problems that were overcome.

Monthly Meeting, 19th July, 1922.

Mr. J. E. Bishop in the Chair.

Mr. Harold Daniell, Managing Director of Perdriau Ltd. gave an address upon "The Manufacture of Rubber Goods." The lecture was illustrated by means of the lantern, the cinematograph and specimens which were distributed among the members.

Monthly Meeting, 16th August, 1922.

Mr. J. E. Bishop in the Chair.

Mr. T. Littlewood, Manager of Brunton & Co's Flour Mills gave an address upon "The Milling of Wheat," which was illustrated by means of a series of lantern slides.

12th and 26th September, 1922.

Instead of the usual monthly meeting, the Section visited the Woollen Mills of John Vicars and Co. Ltd., at Marrickville, and saw the stages in the manufacture of tweeds, worsteds and rugs, beginning with the raw wool and ending with the finished cloth. Late in the month, the Section spent an afternoon at the Dunkerley Hat Mills and saw the various processes in the development of the hat from the rabbit pelt or the greasy wool.

Monthly Meeting 18th October, 1922.

Mr. J. E. Bishop in the Chair.

Mr. C. E. Aitken, Technical Representative of Nestle and Anglo-Swiss Condensed Milk Co., London, gave a lecture upon "The Manufacture of Condensed Milk."

Monthly Meeting, 15th November, 1922.

Mr. Robert Vicars in the Chair.

Mr. Allan G. Garrett, Manager of Harrington's Metallurgical Works, gave an address upon "The Precious Metals: their Application to Industry." The lecture was illustrated by specimens, and special reference was made to the recovery of silver, gold, and platinum from the waste material of the photographic, dental and other industries.

INDEX.

A	Page
Abstract of Proceedings	... iii
Agriculture... ...	xxxvi.
Geological	xxvi.
Industry	... xl.
Acacia acinacea	... 130
Baileyana	... 131
Baueri	.. 130
complanata	... 131
decurrens var. *normalis*	... 131
discolor	... 131
doratoxylon	... 131
elata	... 146
elongata	131, 141
extensa	... 130
floribunda	... 131
hastulata	... 130
homalophylla ...	... 131
implexa	131, 113
juncifolia	... 135
koa	... 131
longifolia	... 131
melanoxylon	... 130
neriifolia	... 131
oxycedrus	... 131
pycnantha	131, 138
rhodoxylon	... 130
rigens ...	131, 134
Seedlings. Part VIII.	... 130
scalpelliformis ...	... 130
sparcifolia ...	... 130
tetragonophylla ...	... 132
trineura	... 131
urophylla	... 130
verniciflua	... 180
verticillata	... 133
vomeriformis ...	... 137
Westoni	131, 140
Agathiceras cisconense ...	... 251
micromphalum ...	... 251
sundaicum	... 251
Alphitonia excelsa	253, 254, 255
Andrews, E. C., Presidential Address	1
Andropogon Jwarancusa	... 173
Anthrax in Stock in Australia, The Incidence of ...	... 44
Australian Melaleucas and their Essential Oils, Part VI, On the	... 115
Australian Plant Products, Part I, Notes on the Chemistry of certain ...	... 180
Aviculopecten	... 249

B	Page
Bacillus colli-ærogenes	286, 287, 289, 294
coli communis ...	... 222
tuberculosis	... 287
typhosus	222, 223
Backhousia myrtifolia, The Essential Oil of ...	... 125
Bœckea crenulata ...	87, 88
Gunniana	... 181
Bacteriological Aspect of Pasteurisation of Milk for Cheddar Cheese-making, Notes on the ...	... 285
Baker, R. T., On the Australian Melaleucas and their Essential Oils, Part VI ...	115
Booth, E. H., Notes on Plate Exposures, and the subsequent Photographic Treatment adopted by the Sydney University Eclipse Expedition	... 185
Brown, Miss Ida, Notes on Hornblende and Bytownite from Hypersthene Gabbro, Black Bluff, near Broken Hill ...	210
Browne, W. R., On an Olivine-bearing Quartz-Monzonite from Kiandra, N.S.W. ...	260
Note on the Occurrence of Calcite in a Basalt from the Maitland District, N.S.W.	278

C	
Cambage, R. H., Acacia Seedlings, Part VIII	130
Centenary Celebrations ...	1
Chamælaucium plumosa	63
Cheddar Cheese-making, Notes on the Bacteriological Aspect of Pasteurisation of Milk for	285
Cheel, Edwin, Notes on the Genera Darwinia Homoranthus and Rylestonea in N. S. Wales, Queensland, and South Australia ...	62
Notes on *Melaleuca linariifolia* Sm., and *M. trichostachya* Lindl.	78
Chemistry of the Phellandrenes, A Contribution to the ...	176
Chonetes strophopmenoides ...	252

Page
Closing up of Phyllodes at night 131
Contribution to the Hypothesis of Coral Reef Formations, A 10
Cœlostat ... ... xvi.
Chocolate Shale... ... xxvi.
Coral Reef Formations, A Contribution to the Hypothesis of 10
Croweacin 228
Crowea saligna 227
Cryptostemon ericaeus 70

D

Darwinia verticordina 67
Darwinia fascicularis 62, 63, 68, 69 70
grandiflora ... 68, 74, 87, 88
Homoranthus and Rylstonea in New South Wales, Queensland, and South Australia, Notes on the Genera 62
intermedia 71, 72
laxiflora 71, 72
micropetala 69
Schuermanni ... 66, 69
Thomasii 68, 69
taxifolia 62, 68, 72, 73, 74, 77
var. *biflora* 68
var. *grandiflora* 73, 74
var. *intermedia*... 69, 73
taxifolius 74
virgata 75
David, Sir Edgeworth, Notes on the Occurrence of Gastrioceras at the Irwin River Coal-Field, W.A., and a comparison with the so-called Paralegoceras from Letti, Dutch East-Indies 249
Dielasma... 252
Dodd, Sydney, Poisoning of Sheep by *Solanum cinereum* 153
Doherty, W. M., Notes on the Food Value of the Snapper and on the Constants of Whale Oil 206
Dun, W. S., Notes on the Occurrence of Gastrioceras at the Irwin River Coal-Field, W. A., and a comparison with the so-called Paralegoceras from Letti, Dutch East Indies 249
Dysoxylon Fraseranum 233, 235, 238, 239
Muelleri 238
Petligrewanum 238

Page
E

Eclipse Expedition, Sydney University, Notes on Plate Exposures, and the subsequent Photographic treatment adopted by the ... 185
Economic Utilisation of the Residues from the Steam Rectification of the Essential Oil of *Eucalyptus cneorifolia* and the Germicidal Values of the Crude Oil and the Pure 'Active' Constituents, The 219
Enosanthus flavescens 76
virgatus 75, 76
Eriostemon Crowei, The Essential Oil of 227
Essential Oil of *Backhousia myrtifolia*, The 125
Kunzea corifolia, The ... 201
Eriostemon Crowei (Crowea saligna) and the presence of a new Phenol Ether... 227
Eucalyptus cneorifolia and the Germicidal Values of the Pure 'Active' Constituents 219
from *Leptospermum Liversidgei* 82
Oils of two Leptospermums 162
of the Myrtaceæ 87
of the species of Homoranthus and the occurrence of Ocimene 193
Eucalyptus acmenioides 245
aggregata 151
amygdalina 176
australiana ... 110, 111, 114
botryoides 151, 244
capitellata 245
citriodora 84
cneorifolia 159, 225
coriacea 150
costata 149
corymbosa 150, 151
corynocalyx 151
crebra ... 244, 245, 247
Dawsoni 244
Delegatensis 241, 243
dives 113, 173
eugenioides 245
hemiphloia 150, 241
lœvopinea 245
ligustrina 150
longifolia 244
Macarthuri 110, 112

	Page
Eucalyptus maculata ...	241, 243
marginata ...	241, 243 244
microcorys	243
nigra	151
Note on the Relationship between Oil Glands and Oil Yields in the ...	149
obliqua	150
obtusiflora	150, 151
odorata	159
oleosa	149
paniculata	247
phytocorpa	150
pilularis	241, 243
polyanthemos	244
polybractea ...	110, 112. 149
propinqua ...	244, 245, 246
punctata	244
regnans	243
resinifera	241, 243
robusta ...	150, 244, 246
rostrata	244
rubida	123, 151
saligna ...	241, 243, 244
siderophloia	245
sideroxylon	245
tereticornis	244, 246
terminalis	149
Euphorbia Drummondii	58, 154

F

Fawsitt, C. E., The Miscibility Test for Eucalyptus Oils...	109
Fischer, C. H., The Miscibility Test for Eucalyptus Oils	109
Flowering Seedlings	131
Fusulina	252

G

Gastrioceras Jacksoni ...	249, 250
Glucoside occurring in the timber of the 'Red Ash' *Alphitonia excelsa* Reiss, The ...	253
Glossopteris	xxxi.
Grant, R., The Economic Utilisation of the Residues from the Steam Rectification of the Essential Oil of *Eucalyptus cneorifolia* and the Germicidal Values of the Crude Oil and the Pure 'Active' Constants... ...	219
Greig, W. A., On an Olivine-bearing Quartz-Monzonite from Kiandra, N.S.W. ...	260

H

	Page
Hardwoods, A method of identification of some	241
Hedeoma pulegioides	172
Henry, Max, The Incidence of Anthrax in Stock in Australia	44
Hornblende and Bytownite from Hypersthene Gabbro, Black Bluff, near Broken Hill, Notes on	210
Hughesdon, R. S., The Stereoisomeric Forms of Menthone	170
Hurst, Eric, A Contribution to the Chemistry of the Phellandrenes	176
Hypothesis of Coral Reef Formations, A Contribution to the	10
Homoranthus darwinioides	69, 77
flavescens	69, 75, 76, 193, 197
virgata	69
virgatus	63, 75, 193, 194, 200, 201
Wilhelmii	69, 77

I

Ice-scratched boulders...	xxvi.
Irwin River Coal Field, W.A., Notes on the Occurrence of Gastrioceras at the... ...	249

J

Jacksoni, Gastrioceras	249

L

Leaves, Sequence in the Development of	130
Leptospermum flavescens	163, 169
var. *leptophyllum*	162, 166, 169
var. *microphyllum*	162, 166, 169
Liversidgei, Observations respecting some Essential Oils from	82
l-Phellandrene in the Oil of *Melaleuca acuminata* of South Australia, On the occurrence of	159
List of Members	ix.

M

Martinia nucla	252
Martiniopsis	xx.
Melaleuca acuminata, On the occurrence of l-Phellandrene in the Oil of ...	159, 161
bracteata	121, 122

Page

Melaleuca Deanei 115, 120, 124
ericifolia ... 79, 115, 116, 118
genistifolia 121, 122
gibbosa 121
leucadendron 116
linariifolia ... 78, 80, 81, 121
nodosa 121, 122
pauciflora 121
thymifolia 121
trichostachya ... 78, 79, 80
trichostachys ... 121, 122
uncinata 121
Menthone, The Stereoisomeric Forms of 170
Micrococcus aureus 222
Milk for Cheddar Cheese-making, Note on the Bacteriological Aspect of Pasteurisation of 285
Morrison, F. R., Preliminary Note on a new Stearoptene (Probably a Phenol Ether) Occurring in some Essential Oils of the Myrtaceæ .. 87
The Essential Oil of *Kunzea corifolia* 201
The Essential Oil of *Eriostemon Crowei* (*Crowea saligna*) and the presence of a new Phenol Ether... 227
Murray, J. K., Notes on the Bacteriological Aspect of Pasteurisation of Milk for Cheddar Cheese-making ... 285

N

Notes on the Bacteriological Aspect of Pasteurisation of Milk for Cheddar Cheese-making 285
Notes on the Occurrence of Gastrioceras at the Irwin River Coal-Field, W.A. ... 249
Notothyris 252

O

Obituary 2–9
Ocimene, The Essential Oils of two species of Homoranthus and the occurrence of ... 193
Oil Glands and Oil Yields in the Eucalyptus, Note on the Relationship between ... 149
Oil of *Backhousia myrtifolia*, The Essential 125

Page

Oil of *Eriostemon Crowei* and the presence of a new Phenol Ether, The Essential ... 227
Eucalyptus cneorifolia and the Germicidal Values of the Crude Oil and the Pure 'Active' Constituents, The Essential .. 219
Kunzea corifolia, The Essential 201
Olivine-bearing Quartz-Monzonite from Kiandra, N.S.W. 260

P

Pacific, The present structure of the 14
The South Western ... 18
Geographical Unity of the 14
Pagrosomus auratus 207
Pasteurisation of Milk for Cheddar Cheese-making, Note on the Bacteriological Aspect of 285
Penfold, A. R., Preliminary Note on a new Stearoptene (Probably a Phenol Ether) Occurring in some Essential Oils of the Myrtaceæ 87
The Economic Utilisation of the Residues from the Steam Rectification of the Essential Oil of *Eucalyptus cneorifolia* and the Germicidal Values of the Crude Oil and of the Pure 'Active' Constituents ... 219
The Essential Oil of *Backhousia myrtifolia*, Part I. 125
The Essential Oil of *Eriostemon Crowei* (*Crowea saligna*) and the presence of a new Phenol Ether 227
The Position of the Double Linkage in Piperitone, Part II, with notes on some of its Derivatives 39
Observations respecting some Essential Oils from *Leptospermum Liversidgei* 82
The Essential Oils of two Leptospermums 162
The Essential Oils of two species of Homoranthus and the occurrence of Ocimene 193

Page
Pinnæ on one Leaf, Number of 130
Piperitone, Part II, The position of the double linkage in ... 89
Plant Products, Part I, Notes on the Chemistry of certain Australian 180
Poisoning of Sheep by *Solanum cinereum* 153
Presidential Address by E. C. Andrews 1
Productus cora 252
spiralis 252

R

Read, John, A contribution to the Chemistry of the Phellandrenes 176
The Glucoside occurring in the Timber of the 'Red Ash' *Alphitonia excelsa*... 252
The Stereoisomeric Form of Menthone 170
Resinous Exudation of Rosewood, The 233
Retzia radialis 252
Rhodosphacra radanthema ... 254
Rosewood, The Resinous Exudation of 233
Rylstonea cernua... 77
Rylstonea in New South Wales, Queensland, and South Australia, Notes on the Genera Darwinia Homoranthus and... 62

S

Sarcostema australe ... 183, 184
Schuermannia homoranthus F.v.M. 66
Sheep by *Solanum cinereum*, Poisoning of 153
Smith, H. G., A Contribution to the Chemistry of the Phellandrenes ... 176
On the Australian Melaleucas and their Essential Oils, Part VI ... 115
On the occurrence of l-Phellandrene in the Oil of *Melaleuca acuminata*, of South Australia... ... 159

Prge
Smith, H. G., The Glucoside occurring in the timber of the 'Red Ash' *Alphitonia excelsa* Reiss ... 253
The Stereoisomeric Forms of Menthone 170
Notes on the Chemistry of certain Australian Plant Products, Part I 180
Snapper and the Constants of Whale Oil, Notes on the Food Value of the 206
Solanum cinereum ... 153, 155
Spirifer rajah 252
reticularia 252
tasmaniensis ... ... xx.
vespertilio ... ... xx.
Streptococcus lactis 286, 291, 292, 293, 294
Syantheria Mexicana 184
Syncarpia laurifolia 245

T

Taylor, J. K., A Chemical and Bacteriological Study of a Typical Wheat Soil of N.S. Wales 90
Tristania conferta 245

V

Vertebraria ... ... xxxi.
Verticordia Fontanesii 63
Darwinioides ... 64, 77
Thomasii 67
Wilhelmii 64, 66, 77
Vitality of Seeds in Sea-Water 130

W

Welch, M. B., A Method of Identification of Some Hardwoods 241
Note on the Relationship between Oil Glands and Oil Yields in the Eucalyptus 149
The Resinous Exudation of Rosewood 233

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